# WHEAT

## THE CROP FOR ENSURING INDIAN FOOD SECURITY

### 1. Prologue:

The cultivation of wheat dates back to more than 5000 years back during the era of Indus valley civilization where the original species was *Triticum Sphaerococcum* popularly known as Indian wheat has now disappeared and replaced by present day species- *Triticum aestivum* or the common Bread Wheat, *Triticum durum* or the Macaroni wheat and the *Triticum dicoccum* or the Emmer Wheat.

During independence, the country was dependent on wheat import to meet the food demand of the country. Due to the lodging prone low yielding nature of Indian wheat under high fertility conditions, there remained a continuous need for a breakthrough in wheat production. The wheat received under PL 480 agreement continued to be the main base on which the large population of India was dependent. It was finally the dream of Dr. Norman E. Borlaug, the father of green revolution during mid sixties that came true to materialize the spurt of the Green Revolution in the Indo gangetic plains by which India became a wheat surplus country from a deficient one. This led to the achievement of as hunger free world by then as India plays a major role in creating a global status of food security. The production level of Wheat in India had a quantum jump from 6.46 million tones from an area of 9.75 million ha in 1950-51 to more than 93 million tones from an area of about 30 million hectares during 2011-12.

Currently, India is second largest producer of Wheat in the world after China with about 12% share in total world Wheat production. Now, India is surplus and in a position to export Wheat in the International Market and can earn foreign exchange. India has exported about 30 lakh tonnes of Wheat worth Rs.1,490 crore during 2001 02. Three species of Wheat namely, (i) T. aestivum, (ii) T. durum and (iii) T. dicoccum are being cultivated in the country , as per details given as under :

| S.No. | Species | % share of Production | MAJOR GROWING AREAS |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **1.** | *T. aestivum* | 95 % | Uttar Pradesh, Punjab, Haryana, Rajasthan, Bihar, West Bengal, Assam, Parts of Madhya Pradesh, Himachal Pradesh, Jammu & Kashmir |
| **2.** | *T. durum* | 4 % | Madhya Pradesh, Maharashtra, Gujarat, Southern Rajasthan and few locations in Punjab. |
| **3.** | *T. dicoccum* | 1 % | Karnataka, Maharastra & Tamil Nadu |

## 2. Area and production of wheat:

### 2.1.The Indian Scenario:

Wheat is grown in India in an area of about 30 Million ha. with a production of 93 Million tonnes. The normal National productivity is about 2.98 tonnes/ha. The major Wheat producing States are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, Maharashtra, Gujarat, Karnataka, West Bengal, Uttarakhand, Himachal Pradesh and Jammu & Kashmir. These States contribute about 99.5% of total Wheat production in the country. Remaining States, namely, Jharkhand, Assam, Chhattisgarh, Delhi and other North Eastern States contribute only about 0.5 % of the total Wheat production in the country. The area, production and yield of wheat in different states of the country are as follows:

**Area, Production and Productivity of wheat in Major wheat growing States of India(2010-11)**

| Sl. No | States | Area | | Production | | Yield |
|---|---|---|---|---|---|---|
| | | Area(Lakh Ha) | % to all India | Production (lakh MT) | % to all India | (Kg/Ha) |
| 1 | Uttar Pradesh | 96.370 | 33.15 | 300.010 | 34.534 | 3113 |
| 2 | Madhya Pradesh | 43.410 | 14.93 | 76.271 | 8.780 | 1757 |
| 3 | Punjab | 35.100 | 12.07 | 164.720 | 18.961 | 4693 |
| 4 | Haryana | 25.150 | 8.65 | 116.300 | 13.387 | 4624 |
| 5 | Rajasthan | 24.792 | 8.53 | 72.145 | 8.305 | 2910 |
| 6 | Bihar | 21.035 | 7.24 | 40.976 | 4.717 | 1948 |

| Sl. No | States | Area | | Production | | Yield |
|---|---|---|---|---|---|---|
| | | Area(Lakh Ha) | % to all India | Production (lakh MT) | % to all India | (Kg/Ha) |
| 7 | Maharashtra | 13.070 | 4.50 | 23.010 | 2.649 | 1761 |
| 8 | Gujarat | 12.740 | 4.38 | 40.195 | 4.627 | 3155 |
| 9 | Uttarakhand | 3.792 | 1.30 | 8.780 | 1.011 | 2316 |
| 10 | Himachal Pradesh | 3.572 | 1.23 | 5.465 | 0.629 | 1530 |
| 11 | West Bengal | 3.168 | 1.09 | 8.744 | 1.007 | 2760 |
| 12 | Jammu & Kashmir | 2.907 | 1.00 | 4.463 | 0.514 | 1535 |
| 13 | Karnataka | 2.550 | 0.88 | 2.790 | 0.321 | 1094 |
| 14 | Chhatisgarh | 1.108 | 0.38 | 1.268 | 0.146 | 1144 |
| 15 | Jharkhand | 0.964 | 0.33 | 1.584 | 0.182 | 1642 |
| 16 | Assam | 0.448 | 0.15 | 0.528 | 0.061 | 1179 |
| 17 | Delhi | 0.256 | 0.09 | 1.110 | 0.128 | 4340 |
| 18 | Andhra Pradesh | 0.100 | 0.03 | 0.130 | 0.015 | 1300 |
| 19 | Arunachal Pradesh | 0.037 | 0.01 | 0.059 | 0.007 | 1595 |
| 20 | Nagaland | 0.031 | 0.01 | 0.053 | 0.006 | 1712 |
| 21 | Orissa | 0.029 | 0.01 | 0.042 | 0.005 | 1458 |

| Sl. No | State | Area | | Production | | Yield |
|---|---|---|---|---|---|---|
| | | Area(Lakh Ha) | % to all India | Production (lakh MT) | % to all India | (Kg/Ha) |
| 22 | Sikkim | 0.027 | 0.01 | 0.027 | 0.003 | 1023 |
| 23 | Manipur | 0.021 | 0.01 | 0.053 | 0.006 | |
| 24 | Meghalaya | 0.004 | 0.00 | 0.007 | 0.001 | 1791 |
| 25 | Tripura | 0.003 | 0.00 | 0.006 | 0.001 | 2025 |
| 26 | D & N Haveli | 0.001 | 0.00 | 0.003 | 0.000 | 2231 |
| 27 | Tamil Nadu | 0.001 | 0.00 | 0.000 | 0.000 | |
| 28 | Others | 0.000 | 0.00 | 0.000 | 0.000 | |
| | **All India** | **290.686** | **100.00** | **868.740** | **100.000** | **2989** |

It would be seen from above table that in terms of area, the state of Uttar Pradesh stands first followed by Madhya Pradesh, Punjab, Haryana, Rajasthan,Bihar, Maharashtra, Gujarat, , Himachal Pradesh, West Bengal, Karnataka and Jammu & Kashmir. In terms of production, U.P. again occupies first place followed by Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, Maharashtra, Gujarat, West Bengal, Uttarakhand, Himachal Pradesh, Jammu & Kashmir and Karnataka. The contribution of these states in the production is about 99.5% . The contribution of other States is minimal. As regards to the productivity, Punjab stands first (4531 Kg/ha.) followed by Haryana (4066 Kg/ha.), Uttar Pradesh (2691 Kg./ha.), Rajasthan (2481 Kg/ha.), West Bengal (2321 Kg/ha.), Gujarat (2294 Kg/ha.), Bihar (2143 Kg/ha.), Uttarakhand (1873 Kg/ha.), Madhya Pradesh (1753 Kg/ha.), Himachal Pradesh (1609 Kg/ha.), Maharashtra (1310 Kg/ha.), Jammu & Kashmir (1239 Kg/ha.) and Karnataka (855 Kg/ha.).

## 2.2. World Scenario

The total area under Wheat in the world is around 225.62 million ha. with a production of 685.6 million tonnes (2009-10). The normal world productivity is 3039 Kg./ha. The major Wheat producing countries are China, India, USA, France, Russia, Canada, Australia, Pakistan, Turkey, UK, Argentina, Iran and Italy. These countries contribute about 76% of the total world Wheat production

**Area, Production and Yield of major crop growing countries(2009-10)**

| Country | Area(Lakh Ha) | Production(lakh MT) | Yield(Kg/Ha) | % to World Production |
|---|---|---|---|---|
| China | 242.91 | 1151.15 | 4739 | 16.79 |
| India | 277.50 | 806.80 | 2907 | 11.77 |
| Russian Federation | 266.33 | 617.40 | 2318 | 9.01 |
| U.S.A. | 201.81 | 603.14 | 2989 | 8.80 |
| France | 51.47 | 383.32 | 7447 | 5.59 |
| Canada | 96.38 | 268.48 | 2786 | 3.92 |
| Germany | 32.26 | 251.90 | 7808 | 3.67 |
| Pakistan | 90.46 | 240.33 | 2657 | 3.51 |
| Australia | 135.07 | 216.56 | 1603 | 3.16 |
| Ukraine | 67.53 | 208.86 | 3093 | 3.05 |
| Turkey | 80.27 | 206.00 | 2566 | 3.00 |
| Kazakhstan | 143.29 | 170.52 | 1190 | 2.49 |
| U.K. | 18.14 | 143.79 | 7927 | 2.10 |
| Iran | 66.47 | 134.85 | 2029 | 1.97 |
| **Country** | **Area(Lakh Ha)** | **Production(lakh MT)** | **Yield(Kg/Ha)** | **% to World Production** |

| | | | | |
|---|---|---|---|---|
| Poland | 23.46 | 97.90 | 4173 | 1.43 |
| Egypt | 13.22 | 85.23 | 6448 | 1.24 |
| Argentina | 43.35 | 75.73 | 1747 | 1.10 |
| Italy | 17.96 | 63.41 | 3532 | 0.92 |
| Romania | 21.41 | 52.03 | 2430 | 0.76 |
| Spain | 17.68 | 47.24 | 2672 | 0.69 |
| Syria | 14.37 | 37.02 | 2575 | 0.54 |
| Bangladesh | 3.95 | 8.49 | 2149 | 0.12 |
| **World** | 2256.22 | 6856.14 | 3039 | 100.00 |

India stands first in area and second in production next to China in the world . The India's share in world Wheat area is about 12.40%, whereas it occupies 11.77 % share in the total world Wheat production. There is hardly any scope for expansion of area under Wheat. The main emphasis would be on increasing the productivity of Wheat by adopting the improved cultivation practices.

## 2.3. Gap in Yield with other countries

| Country | Yield(Kg/Ha) | Yield Gap (-/+ Kg/Ha over Indian Productivity) |
|---|---|---|
| U.K. | 7927 | 5020 |
| Germany | 7808 | 4901 |
| France | 7447 | 4540 |
| Egypt | 6448 | 3541 |
| China | 4739 | 1832 |
| Poland | 4173 | 1266 |
| Italy | 3532 | 625 |
| Ukraine | 3093 | 186 |
| U.S.A. | 2989 | 82 |
| India | 2907 | 0 |
| Canada | 2786 | -121 |
| Spain | 2672 | -235 |
| Pakistan | 2657 | -250 |
| Syria | 2575 | -332 |
| Turkey | 2566 | -341 |

| **Country** | **Yield(Kg/Ha)** | **Yield Gap (-/+ Kg/Ha over Indian Productivity)** |
|---|---|---|
| Romania | 2430 | -477 |
| Russian Federation | 2318 | -589 |
| Bangladesh | 2149 | -758 |
| Iran | 2029 | -878 |
| Argentina | 1747 | -1160 |
| Australia | 1603 | -1304 |
| Kazakhstan | 1190 | -1717 |
| **World** | 3039 | 132 |

### 3.0. Indian Wheat Growing Zones:

The entire wheat growing areas of the country has been categorized into 6 major zones as follows:

| Sl.no. | Zones | States/regions covered | Approx Area(million ha) |
|---|---|---|---|
| 1 | **Northern Hill Zone(NHZ)** | Hilly areas of J&K( except Jammu, Kathua and Samba districts), Himachal Pradesh ( except Una & Paonta valley),Uttarakhand(excluding Tarai region) & Sikkim | 0.8 |
| 2 | **North Western Plains Zone(NWPZ)** | Punjab,Haryana,Western UP(except Jhansi Div),Rajasthan (excluding Kota & Udaipur div),Delhi, Tarai region of Uttarakhand, Una & Paonta valley of HP, Jammu,Samba & Kathua districts of J&K and Chandigarh. | 11.55 |
| 3 | **North Eastern Plains Zone(NEPZ)** | Eastern UP(28 dist),Bihar,Jharkhand,West Bengal,Assam, Odisha and other NE states (except Sikkim) | 10.5 |
| 4 | **Central Zone** | MP,Gujarat,Chattisgarh,Kota & Udaipur Div of Rajasthan & Jhansi Div of UP. | 5.2 |
| 5 | **Peninsular Zone** | Maharashtra, Tamil Nadu(except Nilgiris & Palani Hills),Karnataka & Andhra Pradesh | 1.6 |
| 6 | **Southern Hill Zone(SHZ)** | Nilgiris & Palani Hills of Tamil Nadu | 0.1 |

**Important Zones for cultivation in Bihar -**

Based on soil characterization rainfall, temperature and terrain four main agro climatic zones in

Bihar have been identified these are:-

1. **Zone- I : North alluvial plain-** Consisting of districts viz. Saran, Siwan, Gopalganj, Muzaffarpur, Vaishali,East Champaran, West Champaran, Sitamarhi, Sheohar, Darbhanga, Samastipur, Madhubani and Begusarai.
2. **Zone-II : North east alluvial plain -** Consisting of districts viz. Purnia, Kishanganj, Katihar, Araria, Saharsa, Supaul, Madhepura and Khagaria.
3. **Zone-III A : South East alluvial plain-** Consisting of districts viz. Bhagalpur, Banka, Munger, Sheikhpura, Jamui and Lakhisarai.
4. **Zone III B : South West alluvial plain-** Consisting of districts viz. Patna, Nalanda, Rohtas, Bhojpur, Buxar, kaimur, Gaya, Nawada, Jahanabad, Arwal and Aurangabad.

1. **Important zones of Gujarat**

| **Zone** | **Name** | **Districts covered** | **% area covered** |
|---|---|---|---|
| IV | North Gujarat | Part of Ahmedabad, Mehsana, Banaskantha, Gandhinagar and Sabarkantha | 30 |
| III | Middle Gujarat | Vadodara, panchmahals and Kheda | 23 |
| V | North-West Gujarat | Kutch, Part of Surendranagar, Banaskantha and Rajkot | 14 |
| VII | South Saurashtra | Whole of Junagadh and parts of Bhavnagar | 13 |
| VI | Saurashtra | Parts of Rajkot, Bhavnagar, Jamnagar and Amreli | 9 |
| VIII | Bhal and Coastal | Parts of Ahmedabad, Bhavnagar and Bharuch | 7 |
| II | South Gujarat | North part of Surat, Bharuch | 3 |
| I | South Gujarat Heavy Rainfall | Dangs, Valsad and South parts of Surat | 1 |

| Agro-climatic Zone of Uttar Pradesh | | |
|---|---|---|
| Sl.No. | Name of Zone | Districts |
| 1 | Bhabhar and Tarai Zone | Bijnour, Pilibhit and Rampur |
| 2 | Bundelkhand Zone | Banda, Chitrakoot, Hamirpur,Jalaun, Jhansi,Lalitpur and Mahoba |
| 3 | Central Zone | Allahabad, Auraiya, Etawah, Farrukhabad,Fatehpur, Hardoi,Kannauj, Kanpur Dehat, Kaushambi, Lucknow, Pratapgarh, Raebareli, Sitapur and Unnao. |
| 4 | Eastern Plain Zone | Ambedkar nagar, Azamgarh, Ballia, Barabanki, Chandauli,Faizabad, Ghazipur, Jaunpur, Mau, Sultanpur and Varanasi. |
| 5 | Mid Western Plain Zone | Badaun, Bareilly, Moradabad and Shahjahanpur. |
| 6 | North Eastern Plain Zone | Bahraich, Balrampur, Basti,Deoria,Gonda, Gorakhpur, Kushinagar, Lakhimpur kheri,Maharaj ganj, Sant Kabir Nagar, Shravasti and Siddharth Nagar. |
| 7 | South Western Semi Arid Zone | Agra, Aligarh,Etah, Firozabad, Mahamaya nagar, Mainpuri and Mathura. |
| 8 | Vindhyan Zone | Mirzapur, Sant Ravidas nagar and Sonbhadra. |
| 9 | Western Plain Zone | Baghpat, Bulandsahar, Gbnagar, Ghaziabad, Meerut, Muzfarnagar and Saharanpur. |

## 4.0. Varietal Development:

There are at present about 371 varieties released so far by the CVRC and SVRC of the states. Of these 314 were bread wheat, 49 durum wheat and 5 dicoccum wheat besides 3 Triticales.

**4.1. Development of improved wheat varieties :** The All India Coordinated Wheat and Barley Improvement Project conducts a number of well-organized multi-location yield trials for different production conditions. This testing has contributed in release of wheat varieties suited to different environments and growing situations. The prominent ones are Kalyansona, Sonalika, Lerma Rojo, Chhoti Lerma, Arjun, C 306, WL 711, UP 262, LOK 1, HUW 206, HUW 234, HD 2189, HD 2329, HD 2285, Raj 3077, PBW 34, WH 147, Sujata, VL 421, VL 616, HS 240, HS 295, UP 2338, PBW 343, PBW 502, GW 322, GW 496, Raj 3765 in bread wheat and Raj 1555, PBW 34, HI 8381, HI 8498, PDW 233 and PDW 291 in durum wheat. Varieties have also been developed and released for high altitude areas, suppressive (salt affected) soils, harsh conditions (central India),and hot and humid environments prevailing in north east. Varieties have also been released for moisture stress conditions, both in bread and durum wheat. Many varieties developed by the project are also under cultivation in many of the foreign countries.

**4.2. Wheat and triticale varieties released in India during 1965-2006:**

| **Species** | **No. of varieties Released by** | | **Total** |
|---|---|---|---|
| | **CVRC** | **SVRC** | |
| Bread wheat *(Triticum aestivum)* | 175 | 95 | 270 |
| Durum wheat *(Triticum durum)* | 17 | 18 | 35 |
| Dicoccum wheat *(Triticum dicoccum)* | 04 | - | 04 |
| Triticale | 01 | 02 | 03 |

**4.3.Some important wheat varieties released during 1990-2006:**

| **Zone** | **Production conditions** | | |
|---|---|---|---|
| | **Normal sown** | **Late sown** | **Rainfed** |
| **North Western Plain Zone** | | | |
| Bread wheat | WH 542, PBW 343 PBW 502, UP 2338, DBW 17, Raj 3077*, KRL-19* | DBW 16, PBW 373 UP 2338, UP 2425, HD | PBW 299,PBW 396, WH 533 |
| **Durum** | PDW 291, PBW 34, PDW 215, PDW 233, WH 896 | | - |
| **North Eastern Plains Zone** | | | |
| Bread wheat | K 8804, K 9107, HUW 468, PBW 443, DL 784-3, K 0307 HP 1731, HP 1761, HD 2733 NW 1012, HD 2824, Raj 3077*, | DL 784-3, HD 2643, HP 1633,HP 1744, NW 1014, HW 2045, DBW 14, NW 2036 | K 8962, K 9465, K 8027, HD 2888 |
| **Central Zone** | | | |
| Bread wheat | GW 190, GW 273, GW 322 GW 366, Raj 3077*, KRL-19* | GW 173, DL 788-2 MP 4010, HD 2864 | HW 2004, JWS 17, HI 1500, HI 1531 |
| **Durum** | HI 8381, HI 8498 | - | HD 4672, HI 8627 |
| Dicoccum | DDK 1001, DDK 1025, DDK 1009 | - | - |

| Zone | Production conditions | | |
|---|---|---|---|
| | **Normal sown** | **Late sown** | **Rainfed** |
| | | **Peninsular Zone** | |
| Bread wheat | HD 2189, DWR 162, GW 322, MACS 2496 RAJ 4037, NIAW 917 | DWR 195, HD 2501, NIAW 34, HD 2833, HUW 510, | K 9644, HD 2781 |
| Durum | MACS 2846 | - | AKDW 2997-16 |
| Dicoccum | DDK 1001, DDK 1009, DDK 1025 | - | - |
| | | **Northern Hills Zone** | |
| Durum | VL 738, VL 804, HS 240 | HS 295, HS 420 | VL 738, HPW 42, HS 365, VL829, VL832, SKW 196 |
| Triticale | - | - | DT 46 |
| | | Southern Hills Zone | |
| Bread wheat | HUW 318, HW 1085, HW 2044 | - | - |

*: Sodic soils ***Source: DWR Perspective Plan Vision 2025***

5.0. WHEAT VARIETIES RELEASED FROM 1995 -2008

**5.1.CENTRAL RELEASE VARIETIES :**

| Cultivar | Year of release / Notification | Originating Breeding Institute | Recommended for | | | Av. Yield under optimum | Special Features |
|---|---|---|---|---|---|---|---|
| | | | Conditions | States/Area/ Region | Agro-climatic Zone | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| WH-896[durum] | 1995 | CCS HAU, Hissar | Timely sown, irrigated condition | Punjab, Haryana, Delhi, Rajasthan, Western Uttar Pradesh, parts of J & K (Jammu & Kathua Distt.) and parts of H.P. (Paonta Valley & Una Distt.) | NWPZ | - | - |
| PBW- 343 | 1996 | PAU, Ludhiana | Timely sown, irrigated condition | Punjab, Haryana, Delhi, Rajasthan, Western Uttar Pradesh, parts of J & K (Jammu & Kathua Distt.) and | NWPZ | 50 | Wide adaptability, high degree of resistance to rusts (brown & yellow) and tolerance to Karnal Bunt. The grains are amber, semi hard to hard, good straw strength resulting in high |
| PBW – 373 | 1997 | PAU, Ludhiana | Very late sown, irrigated condition. | Punjab, Haryana, Delhi, Rajasthan, Western Uttar Pradesh, parts of J & K (Jammu & Kathua Distt.) and | NWPZ, | 42 | High yielding and disease resistant variety possessing late heat tolerance. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ganga (HD 2643) | 1997 | IARI, New Delhi | Late sown, irrigated condition | Area stretching from Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West | NEPZ | 35- 40 | Waxy ear head, amber grains with hard texture, possess good chapati making quality. Resistance to leaf & stripe rusts and tolerant to karnal bunt & leaf |
| UP -2425 | 1999 | GBPUAT, Pantnagar | Late sown, irrigated condition | Punjab, Haryana, Delhi, Rajasthan, Western Uttar Pradesh, parts of J & K (Jammu & Kathua Distt.) and | NWPZ | - | - |
| PBW-443 | 2000 | PAU, Ludhiana | Timely sown, irrigated condition | Area stretching from Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West Bengal, Assam | NEPZ | 40 | - |
| PBW – 373# | 2000 | PAU, Ludhiana | Very late sown, irrigated condition. | Area stretching from Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West Bengal, Assam | NEPZ | 42 | High yielding and disease resistant variety possessing late heat tolerance. |
| PBW- 343# | 2000 | PAU, Ludhiana | Timely sown, irrigated condition | Area stretching from Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West | NEPZ | 50 | Wide adaptability, high degree of resistance to rusts (brown & yellow) and tolerance to Karnal Bunt. The grains are amber, semi hard to hard, good straw strength resulting in high |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HD-4672 (duram) Malav Ratna | 2000 | IARI Regional Research Statio n, Indore | Timely sown , rainfed conditio n. | Madhya Pradesh, Gujarat, part of Rajasthan (excluding the districts of Alwar, Bharatpur & Sriganganagar) and | CZ | 35.0 | Medium late maturity and white at maturity. Ears glabrous & black awned. Grains very bold, having good quality traits. Highly resistant to stem & leaf rusts. |
| Lok-45Φ | 2002 | WRS, Lok Bharti, Bhavnag ar | Irrigated, Late sown conditio | Maharashtra, Andhra Pradesh, Karnataka, Goa & plains of Tamil Nadu | PZ | 43 | Intermediates growth habit, early maturity (94 days), amber, semi-hard and medium grains (1000 grains wt.- |
| GW-1189* | 2003 | WRS, GAU , Vijapur | Timely sown, irrigate d | Maharashtra, Andhra Pradesh, Karnataka, Goa & plains of Tamil Nadu | PZ | - | - |
| NIDW-295* | 2003 | MPKV, ARS , Niphad | Timely sown, irrigate d | Maharashtra, Andhra Pradesh, Karnataka, Goa & plains of Tamil Nadu | PZ | - | - |
| UP-2565* | 2003 | GBPUA T, Pantnag ar | Late sown , irrigated condition | Maharashtra, Andhra Pradesh, Karnataka, Goa & plains of Tamil Nadu | PZ | - | - |
| HD-2833* | 2003 | IARI, New Delhi | Late sown, irrigate d conditio n | Maharashtra, Andhra Pradesh, Karnataka, Goa & plains of Tamil Nadu | PZ | - | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| VL-829 | 2003 | VPKA S, (Almora) | Early sown , Rainfed, Low | Hilly regions of J & K (except Jammu & Kathua Distt.), Hills of H.P. (except Paonta Valley & Una Distt.) and Hills | NHZ | 29 | Semi-spreading type, Late maturing (208 days), Amber, semi hard & bold grains (1000 grains wt.-45g) |
| HS-420 (Shivalik) | 2003 | IARI Regional Station, Shimla | Late sown, Restricted | Hilly regions of J & K (except Jammu & Kathua Distt.), Hills of H.P. (except Paonta Valley & Una Distt.) and Hills | NHZ | 27 | Erect type, amber, semi-hard and smaller grains (1000 grains wt.-35g) |
| HS- 375 (Himgiri) | 2003 | IARI Regional Station, | Timely sown, Summer | Very high altitude | NHZ | 27 | Amber, semi-hard and very bold grains (1000 grains wt.-50g) |
| HPW-155* | 2003 | CSKHPKVV, Palampur | Rainfed, Timely sown, Low fertility, High Altitude conditio n | Hilly regions of J & K (except Jammu & Kathua Distt.), Hills of H.P. (except Paonta Valley & Una Distt.) and Uttaranchal. | NHZ | - | - |
| DBW-14 | 2003 | DWR, Karnal | Irrigated, Late sown conditio n | Area stretching from Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West Bengal, Assam | NEPZ | 43 | Early maturity (102 days), amber & hard grains, 1000 grains wt.-40g. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NW-2036 | 2003 | NDUA&T, Faizabad | Irrigated, Late sown condition | Area stretching from Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West Bengal, Assam | NEPZ | 43 | Intermediates growth habit, early maturity (108 days), amber, semi-hard and smaller grains (1000 grains wt.- 36g). |
| MACS-6145* | 2003 | ARI, MACS, Pune | Rainfed, Timely sown condition | Area stretching from Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West Bengal, Assam | NEPZ | - | - |
| MP- 4010 | 2003 | JNKV V, Gwalior | Irrigated, Late sown condition | Madhya Pradesh, Gujarat, part of Rajasthan (excluding the districts of Alwar,Bharatpur & Sriganganagar) & | CZ | 40 | Early maturity (108 days), Amber, hard and medium grains (1000 grains wt.- 40g). |
| HI- 1500 (Amrita) | 2003 | IARI, Regional Station, | Rainfed, Low fertility condition | Madhya Pradesh, Gujarat , part of Rajasthan (excluding the districts of Alwar , Bharatpur & | CZ | 16 | Semi-erect type, days to maturity (120 days), amber, hard and bold grains (1000 grains wt.-42g) |
| HD-2824 | 2004 | IARI, New Delhi | Timely sown, irrigated condition | Area stretching from Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West Bengal, Assam | NEPZ | - | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HW-5001¥ | 2004 | IARI, RS, Wellington | Timely sown, Restricted Irrigated, | Hilly areas of Tamil Nadu and Kerala. | SHZ | 44.2 | High degree of resistance to stem, leaf & Stripe rusts, bold grains, better appearance, good chapatti making quality. |
| PBW-524¥ | 2004 | PAU, Ludhiana | Late sown, irrigated condition | Area stretching from Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West | NEPZ | 35.8 | High degree of resistance to leaf & Stripe rusts, bolder grains,best chapatti making quality. |
| VL-832 | 2004 | VPKAS, Almora | Rainfed, Timely sown, Low fertility , High Altitude condition | Hilly regions of J & K (except Jammu & Kathua Distt.), Hills of H.P. (except Paonta Valley & Una Distt.) and Uttaranchal. | NHZ | - | - |
| SKW-196¥ | 2004 | SKUAST, Srinagar | Timely sown, Rainfed/Restricted Irrigated' Higher Hills | Hilly regions of J & K (except Jammu & Kathua Distt.), Hills of H.P. (except Paonta Valley & Una Distt.) and Uttaranchal. | NHZ | 22.9 | Resistant against stripe rust and field resistance against leaf rust. |
| PBW-502 | 2004 | PAU, Ludhiana | Timely sown, irrigated condition | Punjab, Haryana, Delhi, Rajasthan, Western Uttar Pradesh, parts of J & K (Jammu & Kathua Distt.) and | NWPZ | - | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PDW-291 (durum)¥ | 2004 | PAU, Ludhiana | Timely sown, irrigated condition | Punjab, Haryana, Delhi, Rajasthan, Western Uttar Pradesh, parts of J & K (Jammu & Kathua Distt.) and parts of | NWPZ | 48.5 | Higher level of resistance to rusts, Karnal Bunt, Loose Smut, Flag smut & Head scab diseases, better lodging resistance, high beta carotene content & low yellow berry content | |
| PBW-527¥ | 2004 | PAU, Ludhiana | Timely sown/Rainfed condition | Punjab, Haryana, Delhi, Rajasthan, Western Uttar Pradesh, parts of J & K (Jammu & Kathua Distt.) and | NWPZ | 34.7 | High degree of resistance to Stripe & leaf rusts. | |
| PBW-524¥ | 2004 | PAU, Ludhiana | Late sown, irrigated condition | Madhya Pradesh,Gujarat, part of Rajasthan (Kota and Udaipur Div.) and U.P. | CZ | 40.7 | High degree of resistance to Stripe & leaf rusts, Karnal Bunt, better bread sore & bread loaf volume. | |
| HD-2864¥ | 2004 | IARI, New Delhi | Late sown, irrigated condition | Madhya Pradesh,Gujarat, part of Rajasthan (Kota and Udaipur Div.) and U.P. | CZ | 41.7 | Resistant to leaf & Stripe rusts, heat tolerance, high grain hardness leading to more flour recovery, good chapatti and bread making | |
| RAJ-4037 | 2004 | ARS, RAU, Durgapura | Timely sown, irrigated | Maharashtra, Andhra Pradesh, Karnataka, Goa & plains of Tamil Nadu | PZ | - | - | |
| NIAW 917 ^ | 2005 | ARS, Niphad | Irrigated, Timely sown | Maharashtra, Andhra Pradesh, Karnataka, Goa & plains of Tamil Nadu | PZ | 45.3 | | |
| PBW 533^ | 2005 | PAU, Ludhiana | Irrigated, Late sown | Maharashtra, Andhra Pradesh, Karnataka, Goa & plains of Tamil Nadu | PZ | 40.4 | Suitable for bread and buiscut | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| AKDW 2997-16^ | 2005 | PDKV, Akola | Rainfed, timely Sown conditio | N.Karnataka, S. Maharastra. A.P, and Tamilnadu | PZ | 11.58 | | |
| DDK 1025 Dicoccum^ | 2005 | UAS, Dharwad | Irrigated, Timely sown conditio | N.Karnataka, S. Maharastra. A.P, and Tamilnadu | PZ | 42.4 | | |
| HI-8627 ¥ | 2004 | IARI,RS, Indore | Timely sown, Rainfed/Re str icted Irrigated condition | Madhya Pradesh,Gujarat, part of Rajasthan (Kota and Udaipur Div.) and U.P. (Jhansi Div.) | CZ | 16.7 (Rainfed) 25.8 (Restrict ed | High degree of resistance to leaf & Stripe rusts and foot rot, bold lustrous grains with low yellow berry content, good protein, beta carotene | |
| HI 1531^ | 2005 | IARI,RS, Indore | Timely sown, Rainfed and Restricted irrigated | Madhya Pradesh,Gujarat, part of Rajasthan (Kota and Udaipur Div.) and U.P. (Jhansi Div.) | CZ | 23.6 | | |
| HD 2888^ | 2005 | IARI, New Delhi | Rainfed, Timely sown condition | Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West Bengal, Assam & Plains of NE region | NEPZ | 23.3 | | |
| K0307< | 2006 | CSA, Kanpur | Timely sown High fertility condition | Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West Bengal, Assam & Plains of NE region | NEPZ | 45.6 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DBW 17< | 2006 | DWR, Karnal | Irrigated, Timely sown condition | Punjab, Haryana, Delhi, Rajasthan, Western Uttar Pradesh, parts of J & K (Jammu & Kathua Distt.) and parts of H.P. (Paonta Valley & Una Distt.) | NWPZ | 49.03 | |
| TL- 2942< | 2006 | PAU, Ludhiana | Rainfed, timely Sown condition | Hilly regions of J & K (except Jammu & Kathua Distt.), Hills of H.P. (except Paonta Valley & Una Distt.) and Uttaranchal. | NHZ | 26.1 | |
| GW-366< | 2006 | JAU, Junagarh | Irrigated, Timely sown condition | Madhya Pradesh,Gujarat, part of Rajasthan (Kota and Udaipur Div.) and U.P. (Jhansi Div.) | CZ | 51.7 | |
| DDK-1029< | 2006 | UAS, Dharwad | Irrigated, Timely sown condition | N.Karnataka,<br>S. Maharastra. A.P, and Tamilnadu | PZ | 42.7 | |
| HI- 8663(d) | 2007 | | Timely sown, High fertility irrigated | Maharashtra and Karnataka | PZ | 45.4 to 71.5 | |
| HI-1544 | 2007 | | Timely sown, High fertility irrigated | Madhya Pradesh, Gujarat, part of Rajasthan (Kota and Udaipur Div.) | CZ | 47.7 to 62.4 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HD-2932 | 2007 | | Late sown, Medium fertility Irrigate | Madhya Pradesh, Chhattisgarh, Gujarat, part of Rajasthan (Kota and Udaipur Div.) Maharashtra and Karnataka | CZ | 43.3 to 53.6 | |
| PBW-550 | 2007 | | Timely sown, High fertility irrigated condition | Punjab, Haryana, Delhi, Rajasthan (excluding kota & udaipur), Western Uttar Pradesh, Tarai of Uttarakhand and parts of H.P. (Paonta Valley & Una Distt.) | NWPZ | 47.7 to 62.4 | |
| WH-1021 | 2007 | | Late sown, Medium fertility Irrigated conditio | Punjab, Haryana, Rajasthan (excluding kota & udaipur), Western Uttar Pradesh, Tarai of Uttarakhand and parts of H.P. (Paonta Valley & Una Distt.) | NWPZ | 39.0to 62.5 | |
| VL-892 | 2007 | | Late sown, Medium fertility restricted irrigation | Hills of H.P. and Uttarkhand | NHZ | 37.6 to 59.0 | |
| HPW-251 | 2007 | | Early sown, Low fertility Rainfed | Hills of H.P. and Uttarkhand | NHZ | 34-4 to 57.1 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HS – 490 | 2008 | IARI, RRS , SHIMLA | Late sown restricted irrigation | Hilly regions of J & K (except Jammu & Kathua Distt.), Hills of H.P. (except Paonta Valley & Una Distt.) and Uttaranchal. | NHZ | 31.0 | Resistant against leaf and stripe rust with seedling resistant against the most virulent stripe rust pathotype 46S119. |
| PBW - 590 | 2008 | PAU, Ludhiana | Late sown irrigated condition | Punjab, Haryana, Rajasthan (excluding kota & udaipur), Western Uttar Pradesh, Tarai of Uttarakhand and parts of H.P. (Paonta Valley & Una Distt.) | NWPZ | 42.2 | High yielding, leaf rust resistance and high protein content |
| RAJ - 4120 | 2008 | ARS, Durgapur, Jaipur | Timely sown Irrigated condition | Eastern UP onwards upto the Far eastern states viz., Bihar, Orissa, West Bengal, Assam & Plains of NE region | NEPZ | 47.5 | Early maturing variety, highest yield, better resistance to rusts under natural as well as artificial conditions and this variety is genetically blessed with good resistance to rusts and other diseases. It has good |
| M.P 1203 | 2008 | JNKVV, ZARS, Hosangabad (MP) | Late sown, Irrigated condition | Madhya Pradesh, Chhattisgarh, Gujarat, part of Rajasthan (Kota and Udaipur Div.) Maharashtra and Karnataka | CZ | 41.24 | Resistant brown and black rusts, highest protein content, Cu content. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MACS -2971 | 2008 | Agakar Research Institute, Pune | Irrigated, Timely sown condition | N.Karnataka,<br>S. Maharastra. A.P, and Tamilnadu<br>Madhya Pradesh,Gujarat, part of Rajasthan (Kota and Udaipur Div.) and U.P. (Jhansi Div.) | PZ & CZ | 46.5 | High degree of resistance to black & brown rusts. |
| PBW-596 | 2008 | PAU, Ludhiana | Timely sown restricte d | N.Karnataka,<br>S. Maharastra. A.P, and Tamilnadu | PZ | 30.8 | Vary high grain yield potential with bold grain and good grain quality. |
| UAS – 415 (D) | 2008 | UAS, Dharwad | Irrigated, Timely sown condition | N.Karnataka,<br>S. Maharastra. A.P, and Tamilnadu | PZ | 49.6 | Multiple disease resistant, having resistance to all the three rusts, foliar blight, powdery |
| MACS -2971 | 2008 | Agakar Research Institute, Pune | Irrigated, Timely sown condition | N.Karnataka,<br>S. Maharastra. A.P, and Tamilnadu<br>Madhya Pradesh,Gujarat, part of Rajasthan (Kota and Udaipur Div.) and U.P. (Jhansi Div.) | PZ & CZ | 46.5 | High degree of resistance to black & brown rusts. |

**4.2 STATE RELEASE VARIETIES :**

| Sl. No | Cultivar | Year of release/ Notification | Originating Breeding Institute | Recommended for | | | Av. Yield under optimum conditions (qlts. ha.) | Special Features |
|---|---|---|---|---|---|---|---|---|
| | | | | Conditions | States/Area/ | Agro-climatic Zone | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1. | PDW – 233 (durum) | 1997 | PAU, Ludhiana | Timely sown, irrigated | Punjab State | NWPZ | 47 | - |
| 2. | TL-1210 (Triticale) | 1997 | PAU, Ludhiana | Timely sown irrigated | Punjab | NWPZ | - | - |
| 3. | PBW-373 | 1997 | PAU, Ludhiana | Late sown, irrigated | Punjab | NWPZ | 42 | High yielding and disease resistant variety possessing late heat tolerance |
| 4. | Sonak | 1998 | CCSHAU, Hissar | Late sown, very late sown, irrigate | Haryana | NWPZ | - | - |
| 5. | UP-2382 | 1999 | GBPUAT, Pantnaga | Late sown, irrigated | UP state excluding hills. | NWPZ | - | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6. | WH-711 | 2002 | CCSHAU, Hissar | Timely sown, irrigated | Haryana | NWPZ | 59 | Late maturity (145 days), Amber, hard grains, 1000 grain wt. (43g) |
| 7. | WH-912 | 2002 | CCSHAU, Hissar | Timely sown, irrigated | Haryana | NWPZ | 55 | Amber, hard and bold grains(1000 grain wt. 46g), long awns, late maturity (145 days) |
| 8. | PDW – 274 (durum) | 2003 | PAU, Ludhiana | - | Punjab State | NWPZ | - | - |
| 9. | Ujiar (K-9006) | 1998 | CSUAT, Kanpur | Timely sown, irrigated | Uttar Pradesh-East | NEPZ | 45-50 | Amber, semi-hard grains with good chapati making quality, 1000 grain wt.-38g, resistant to different |
| 10. | Gangotri (K-9162) | 2001 | CSUAT, Kanpur | Late sown, irrigated condition | Uttar Pradesh | NEPZ | 35-40 | Early maturity (100 days), Amber, semi-hard & bold grains, 1000 grain wt.-43, good chapati making quality, high degree of tolerance to |
| 11. | Prasad (K-8434) | 2001 | CSUAT, Kanpur | Timely sown, irrigated condition under saline/alkaline soil | Uttar Pradesh | NEPZ | 35-40 | Early maturity (115 days), amber, semi-hard grains, 1000 grains wt.- 42g, excellent bread/chapati making quality. Resistant to all 3 rusts, tolerant to leaf blight, karnal bunt , smut and |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 12. | Halna (K-7903) | 2001 | CSUAT, Kanpur | Late / very late sown, irrigated condition | Uttar Pradesh | NEPZ | Late sown-35-40<br>Very Late Sown-25-30 | Slightly suitable for saline/alkaline soils, amber, semi-hard grains, 1000 grains wt.-38g. Resistant to all 3 rusts, tolerant to leaf blight, karnal bunt , tolerant to |
| 13. | Naina (K-9533) | 2002 | CSUAT, Kanpur | Late sown, irrigated condition | Uttar Pradesh | NEPZ | 40-45 | Amber, semi-hard grains, 1000 grains wt.-39g. Resistant to all 3 rusts, tolerant to smut, leaf blight & karnal bunt, tolerant to high temperature. Protein |
| 14. | HI-1454 (Abha) | 2000 | IARI, Regional Statio | Late sown, irrigated condition | Madhya Pradesh | CZ | | Plants waxy, brown chaff and double dwarf in height. Stable high yield with good grain traits. |
| 15. | HI-1418 (Naveen Chandausi) | 2000 | IARI, Regional Statio | Late sown, irrigated condition | Madhya Pradesh | CZ | | Medium early in maturity. Ears white and glabrous. Grains medium bold, amber and lustrous. Good for chapati making. |
| 16. | MPO-1106 (durum) Sudha | 2003 | JNKVV, ZARS, Powarkheda, | Timely sown, irrigated conditio | Madhya Pradesh | CZ | - | Early maturity (113 days), broad leaves, white, medium & dense ears, long awns. Amber, lustrous, bold & very attractive grains (1000 grains |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 17. | HI-1479 (Swarna) | 2003 | IARI, Regional Statio | Timely sown, irrigated conditio | Madhya Pradesh | CZ | - | Combines early maturity and high yield with rust resistance. Ears are white and glabrous. Long, bold & amber grains having good chapati traits. |
| 18. | Parbhani – 51 | 1996 | MKV, Parbhani | Timely sown, irrigated conditio | Maharashtra State. | PZ | - | Heat tolerant variety |
| 19. | MACS-2694 (*durum*) | 1997 | Agharkar Research Institute, Pune | Timely sown, irrigated | Maharashtra State | PZ | - | - |
| 20. | NIAW-34 | 1997 | MPKV, Niphad | Late sown, irrigated | Maharashtra State | PZ | 36 | - |
| 21. | DWR-185 (*durum*) | 1998 | UAS, Dharwad | Timely sown, irrigated | Karnataka | PZ | 43 | - |
| 22. | NIAW-301 | 2002 | MPKV, Niphad | Timely sown, irrigated | Maharashtra State | PZ | 43 | White ears at maturity, 1000 grain wt. (43g), amber, medium hard grains |
| 23. | Raj- 3777 | 2003 | RAU, Durgapura, Jaipur | Late sown, irrigated | Rajasthan State | - | - | - |
| 24. | MACS-3125 (*durum*) | 2003 | Agharkar Research Institute, Pune | Timely sown, irrigated | Maharashtra State | PZ | 45 | Early maturity (115 days), yellow ears at maturity, amber, hard & bold grains(1000 grains wt.- |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 25. | Surbhi (HPW-89) | 1998 | HPKVV, Palampur | Timely sown, rainfed conditio | Himachal Pradesh | NHZ | - | - |
| 26. | VL-802 | 2003 | VPKAS, Almora | Timely sown, irrigate d/ Rainfed | Uttaranchal hills | NHZ | - | - |

## 4.3. NEW VARIETIES RELEASED DURING 2010-11(49TH AICW&BIP):

| S.No. | Wheat Varieties | Developed by | Production Condition | | Grain yield (Kg/ha) | |
|---|---|---|---|---|---|---|
| | | | | | Average | Potential |
| 1 | VL-907(VL Gahun 907) | VPKAS, Almora | NHZ timely sown | irrigated | 4430 | 5690 |
| | | | | rainfed | 2790 | 4350 |
| 2 | HS507(Pusa Suketi) | IARI, RS, Shimla | NHZ, Timely sown irrigated & rainfed | | 4680 | 6010 |
| 3 | PDW314(d) | PAU, Ludhiana | NWPZ,timely sown irrigated condition | | 5030 | 6610 |
| 4 | WHD943(Durum) | CCSHAU, Hissar | NWPZ, timely sown irrigated condition | | 4820 | 6390 |
| 5 | DBW 39 | DWR, Karnal | NEPZ, timely sown irrigated condition | | 4400 | 5520 |
| 6 | HI 1563(Pusa Prachi) | IARI, RS, Indore | NEPZ, Late sown Irrigated condition | | 3760 | 5170 |
| 7 | MPO-1225(d) | JNKVV, Powarkheda | CZ, timely sown irrigated condition | | 4780 | 6530 |
| 8 | MACS 6222 | ARI, Pune | PZ, timely sown irrigated condition | | 4280 | 6090 |
| 9 | AKAW 4627 | PDKV, Akola | PZ, Late sown Irrigated condition | | 4280 | 6090 |
| 10 | NIAW 1415 (Netravati) | MPKV,ARS,Niphad | PZ, timely sown rainfed & restricted irrigation | | 1950 | 2600 |
| 11 | KRL 210 | CSSRI, Karnal | Salt affected, timely sown rainfed & restricted irrigation | | 3370 | 4930 |
| 12 | KRL 213 | | Salt affected, timely sown rainfed & restricted irrigation | | 3360 | 4390 |

## 4.4. WHEAT VARIETIES RELEASED DURING2011-12(50$^{TH}$ AIW&BWM):

| S.No. | Variety | Developed By | Production Conditions | Yield(kg/ha) | |
|---|---|---|---|---|---|
| | | | | Average | Potential |
| 1 | HD2985 (Pusa Basant) | IARI, New Delhi | NEPZ Late sown Irrigated | 3770 | 5140 |
| 2 | HD2987 (Pusa Bahar) | IARI, New Delhi | PZ , Timely sown rainfed, restricted irrigation | 1750 | 3220 |
| 3 | DPW621-50 | PAU, Ludhiana & DWR, Karnal | NWPZ, Timely sown irrigated | 3150 | 3860 |
| 4 | WH1080 | CCSHAU, Hissar | NWPZ , Timely sown rainfed | 3080 | 4440 |
| 5 | HD2967 | IARI, New Delhi | NWPZ , Timely sown, irrigated | 5040 | 6600 |
| 6 | HD3043 | IARI, New Delhi | NWPZ , Timely sown, restricted irrigation | 4230 | 5020 |

**4.5. Wheat Varieties released during2012-13(51st AIW&BWM) :**

| | | | | | |
|---|---|---|---|---|---|
| 1 | HPW 349 | HPKVV, Palampur | NHZ, it had better resistance to yellow rust 10MS(ACI 2.25) as compared to 30S(ACI 11.25) of HS 526. HPW 349 also out yielded most of the check varieties as well as HS526 at recommended nitrogen application in agronomical trial. | | |
| 2 | WH 1105 | CCSHAU, Hissar | NWPZ, Variety had better resistance to stripe rust and in view of the urgent need for diversity for resistance against stripe rust in NWPZ. This variety also had a distinctadvantageof high yield coupled with early maturity. | | |
| 3 | DBW 71 | DWR, Karnal | NWPZ, the genotype was resistant to stripe rust under field conditions. | | |
| 4 | HD 3059 | IARI, New Delhi | NWPZ, it also had resistance for brown and yellow rust under field condition. | | |
| 5 | RAJ 4229 | RAU, Durgapura, Jaipur | NEPZ ,this variety RAJ 4229 although was similar in yield to check HD2733 had better rust resistance. | | |

| | | | | | |
|---|---|---|---|---|---|
| 6 | HI 8713(D) | IARI, Regional Station, Indore | CZ, It had yield advantage of 4.52% over best check and distinct advantage in quality parameters particularly, high yellow pigment (7.00 ppm) making it good for pasta products. | | |
| 7 | RAJ 4238 | RAU, Durgapura, Jaipur | CZ, the variety though having slight advantage in yield over best check HD2932, showed resistance to rust in field response. | | |
| 8 | MP 3336 | JNKVV, Gwalior | CZ, the variety had slight advantage in yield over best check HD2932, showed resistance to rust in field response. | | |
| 9 | WHD 948 | CCSHAU, Hissar | PZ, WHD 948 showed yield advantage(9.07%) over best check and showed rust resistance in field as well as under artificial conditions. The said variety exhibited | | |
| | | | advantage over checks based on quality parameters also. | | |
| 10 | HW 5216 | IARI, RS, Wellington | SHZ, HW 5216 showed yield advantage(15.44%) over best check and also showed resistance against black and brown rust. | | |

**5.0. Varietal Preference:**

| Wheat type | Production conditions | | | |
|---|---|---|---|---|
| | **Normal sown** | **Late sown** | **Rainfed** | **Sodic soils / Others** |
| **North Western Plains Zone (NWPZ)**<br>*Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), Western UP (except Jhansi division), parts of J&K (Jammu and Kathua districts), HP (Una dist. and Paonta valley) and Uttarakhand(Tarai region)* | | | | |
| **Bread wheat** | DBW 17, PBW 550, PBW 502, PBW 343, WH 542, UP 2338,HD 2687, HD2967 | WH1021, PBW 373, UP 2425, RAJ3077, DBW16, RAJ 3765,PBW 590 | PBW299, PBW 175, WH 533, PBW 396 | RAJ3077, KRL-19, KRL 210, KRL 213 |
| **Durum** | PBW 34, PDW 215, PDW 233, WH 896, PDW 291, PDW 314 | - | - | - |
| **North Eastern Plains Zone (NEPZ)**<br>*Eastern UP, Bihar, Jharkhand, Orissa, West Bengal, Assam and plains of NE States* | | | | |
| **Bread wheat** | CBW 38, Raj 4120, K 0307, NW 1012,UW 68 PBW443,HD2733,HD2824, K9107, HD 2967, DBW 39 | HD2643, HP 1633,HP1744, NW1014, HW 2045, DBW 14, NW2036,HD 2985 | HDR77,K8962, K 9465,K8027, HD 2888, MACS 6145 | RAJ3077, KRL-19 KRL 210, KRL 213 |

**Varietal Preference**

| Wheat type | Production conditions | | | |
|---|---|---|---|---|
| | **Normal sown** | **Late sown** | **Rainfed** | **Sodic soils / Others** |
| **Central Zone (CZ)** *MP, Chhattisgarh, Gujarat, Rajasthan(Kota and Udaipur divisions) and UP( Jhansi division)* | | | | |
| **Bread wheat** | GW 190, GW 273, DL803-3, GW 322, GW 366, HI 1544 | GW 173, DL 788-2, MP 4010, HD 2932, MP 1203, HD 2864 | HW 2004, JWS 17, HI 1500, HI 1531, Sujata | RAJ 3077, KRL-19,KRL 210, |
| **Durum** | HI 8381, HI 8498, MPO 1215 | - | HD 4672, HI 8627 | - |
| **Peninsular Zone (PZ)** *Maharashtra, Karnataka, Andhra Pradesh, Goa, plains of Tamil Nadu* | | | | |
| **Bread wheat** | DWR162, MACS 2496, GW 322, Raj 4037, NIAW 917, UAS 304, MACS 6222, MACS 6273 | DWR 195, HD 2501, NIAW 34, HUW 510, HD 2932, HI 977, HD 2833, PBW 533, Raj 4083, AKAW 4627 | K9644,HD2781, PBW596,HD 2987 | _ |
| **Durum** | MACS 2846, HI 8663, UAS 415 | - | AKDW 2997-16 | - |
| **Dicoccum** | DDK 1025, DDK 1029, DDK 1066 | - | - | - |

## Varietal Replacement

- Replacement of yellow rust susceptible varieties PBW 343, PBW 502 and HD 2687 with DBW 17, PBW 550 & WH 542.

- Under late sown conditions (late basmati-wheat, potato-wheat and sugarcane-wheat)
  - PBW 373 should be replaced with DBW 16, WH 1021, PBW 590, Raj 3765 as PBW 373 has become susceptible to brown rust

Eastern UP, Bihar

- Under TSI conditions, varieties like HD 2733, HD 2824, PBW 443, HUW 468 needs to be promoted and breeder seed production of varieties like UP 262 and HUW 234 should be curtailed.
- Under LSI conditions, varieties like DBW 14, NW 2036, HW 2045, NW 1014, K 8962 and HD 2643 should be promoted.

Madhya Pradesh, Chhatisgarh, Gujarat and Kota region

- Lok 1 is still a reigning variety which needs replacement.
- Under TSI, GW 322, GW 273 while under LSI cnditions HD 2864, MP 4010, DL 788-2 requires promotion.
- For durums HI 8498 and HI 8381 are the best varieties for the area.
- As these states have a sizeable area under rainfed or limited irrigation
  - HI 1531, HI 1500 of bread wheat and HD 4672 and HD 8627 for durum should be promoted while WH 147 should be phased out.

Maharashtra, Karnataka

- For TSI conditions GW 322, RAJ 4037, NIAW 917, DWR 162 and MACS 2496 for bread wheat and MACS 2846 for durum
- LSI sown conditions: PBW 533, HD 2833 and NIAW 34
- Rainfed conditions: HD 2781, K 9644 for bread wheat and AKDW 2997-16 for durum.

Non-traditional wheat growing area - Jharkhand, Orissa, West Bengal and plains of N.E. States; some parts of the plains of Tamil Nadu and Andhra Pradesh

- Due to early onset of rains and to avoid pre-harvest sprouting, these areas require short duration wheat varieties like DBW 14, NW 2036, HW 2045. variety DBW 14 has shown promise in Jharkhand and Assam
- For plains of Tamil Nadu and Andhra Pradesh – a state release variety, CoW(W)-1 has been showing promise.

**6.0 State wise yield potential recorded under FLDs vis-à-vis National/State average yield and gap analysis :**

**6.1.State wise performance of improved Wheat varieties during 2006-07**

| S.No. | State | Mean Yield (qtl/ha) | | | State-wise Av Yield | Gap Between FLDs and State Average Yield | |
|---|---|---|---|---|---|---|---|
| | | Improved | Check Yield | % Gain | | (qtl/ha) | % |
| 1 | UP | - | - | - | 27.21 | - | - |
| 2 | HP | 23 | 20 | 15.00 NS | 13.85 | 9.15 | 39.78 |
| 3 | J&K | 30.24 | 21.11 | 43.25*** | 18.93 | 11.31 | 37.40 |
| 4 | Bihar | 35.69 | 32.16 | 10.98*** | 19.08 | 16.61 | 46.54 |
| 5 | Jharkhand | 15.41 | 13.41 | 14.91** | 15.29 | 0.12 | 0.78 |
| 6 | Punjab | - | - | - | 42.1 | - | - |
| 7 | Haryana | 47.63 | 45.61 | 4.43*** | 42.32 | 5.31 | 11.15 |
| 8 | Uttarakhand | 32.48 | 19.52 | 66.39*** | 20.49 | 11.99 | 36.92 |
| 9 | Gujarat | 39.7 | 37.6 | 5.59 NS | 24.98 | 14.72 | 37.08 |
| 10 | MP | 27.48 | 16.66 | 64.95*** | 18.35 | 9.13 | 33.22 |
| 11 | Chhattisgarh | 25.22 | 17.53 | 43.87*** | 10.02 | 15.2 | 60.27 |
| 12 | Maharashtra | 32.54 | 30.15 | 7.93 NS | 13.25 | 19.29 | 59.28 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | Karnataka | 36.12 | 32.03 | 12.77** | 7.62 | 28.5 | 78.90 |
| 14 | West Bengal | - | - | - | 22.82 | | |
| 15 | Assam | 29.05 | 23.65 | 22.83** | 11.17 | 17.88 | 61.55 |
| 16 | Rajasthan | 43.53 | 39.82 | 9.32** | 27.51 | 16.02 | 36.80 |
| 17 | Tamilndu | 28.94 | - | - | | | |

* Significant at 10%, ** Significant at 5%,*** Significant at 1%, NS- Not significant

**6.2.State wise performance of improved Wheat varieties during 2007-08**

| S.N. | State | Mean Yield (qtl/ha) | | | State-wise Av | Gap Between FLDs and State Average Yield | |
|---|---|---|---|---|---|---|---|
| | | Impr | Ch | % Gain | | (qtl/ha) | % |
| 1 | UP | 46 | 4 | 13.04* | 28.17 | 17.95 | 38.92 |
| 2 | HP | 24 | 2 | 12.96* | 13.76 | 10.65 | 43.63 |
| 3 | J&K | 21 | 1 | 19.01* | 17.82 | 3.4 | 16.02 |
| 4 | Bihar | 39 | 3 | 25.44* | 20.58 | 19.21 | 48.28 |
| 5 | Jharkhand | 38 | 2 | 40.84* | 16.21 | 21.83 | 57.39 |
| 6 | Punjab | 49 | 4 | 3.46** | 45.07 | 3.96 | 8.08 |
| 7 | Haryana | 48 | 4 | 2.59* | 41.58 | 7.19 | 14.74 |
| 8 | Uttarakhand | 34 | 2 | 19.14 | 2 | 14.05 | 40.67 |
| 9 | Gujarat | 46 | 4 | 5.41** | 30.13 | 15.88 | 34.51 |
| 10 | MP | 39 | 2 | 54.25* | 13.76 | 25.28 | 64.75 |
| 11 | Chhattisgarh | 30 | 2 | 44.02* | 10.59 | 19.54 | 64.85 |
| 12 | Maharashtra | 36 | 3 | 17.11* | 16.59 | 19.83 | 54.45 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | Karnatak | 40 | 3 | 16.79* | 9. | 30.74 | 76.47 |
| 14 | West Bengal | 27 | 2 | 31.55* | 26.02 | 1.96 | 7.01 |
| 15 | Assam | 25 | 2 | 23.96* | 12.68 | 13.19 | 50.99 |
| 16 | Rajasthan | 42 | 3 | 10.31* | 27.49 | 14.76 | 34.93 |
| 17 | Tamilnadu | 27 | - | - | | 27.09 | 100.00 |

* Significant at 10%, ** Significant at 5%,*** Significant at 1%, NS- Not significant

**(1) State wise performance of improved Wheat varieties during 2008-09**

| S.N. | State | Mean Yield (qtl/ha) | | | State-wise Av Yield | Gap Between FLDs and State | |
|---|---|---|---|---|---|---|---|
| | | Improved | Check | % Gain | | (qtl/ha) | % |
| 1 | UP | 45.87 | 40.19 | 14.13*** | 30.02 | 15.85 | 34.55 |
| 2 | HP | 23.91 | 18.5 | 29.24*** | 15.2 | 8.71 | 36.43 |
| 3 | J&K | 31.69 | 23.45 | 35.14*** | 17.35 | 14.34 | 45.25 |
| 4 | Bihar | 39.83 | 35.41 | 12.48*** | 20.43 | 19.4 | 48.71 |
| 5 | Jharkhand | 38.4 | 26.22 | 46.45*** | 15.41 | 22.99 | 59.87 |
| 6 | Punjab | 50.46 | 45.08 | 11.93*** | 44.62 | 5.84 | 11.57 |
| 7 | Haryana | 54.24 | 52.26 | 3.79** | 43.9 | 10.34 | 19.06 |
| 8 | Uttarakhand | 31.94 | 24.28 | 31.55NS | 20.03 | 11.91 | 37.29 |
| 9 | Gujarat | 36.4 | 34.34 | 6.00*** | 23.77 | 12.63 | 34.70 |
| 10 | MP | 38.89 | 32.64 | 19.15*** | 17.23 | 21.66 | 55.70 |
| 11 | Chhattisgarh | 40.97 | 27.82 | 47.27*** | 10.4 | 30.57 | 74.62 |
| 12 | Maharashtra | 27.06 | 23.66 | 14.37* | 14.83 | 12.23 | 45.20 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | Karnatak | 40.3 | 34.1 | 18.18*** | 9.18 | 31.12 | 77.22 |
| 14 | West Bengal | | | | 24.9 | | |
| 15 | Assam | 29.52 | 26.41 | 11.77*** | 10.9 | 18.62 | 63.08 |
| 16 | Rajasthan | 41.46 | 35.7 | 16.13*** | 31.75 | 9.71 | 23.42 |
| 17 | Tamilnadu | 31.2 | - | - | | 31.2 | 100.00 |

Si*gnificant at 10%, ** Significant at 5%,*** Significant at 1%, NS- Not significant

**(2) State-wise Analysis/Difference between FLDs and State Average Yield of Wheat during 2009-10**

| Sl.No. | States | Mean yield (q/ha) | | % Gain | State-wise Av Yield | Gap Between FLDs and | |
|---|---|---|---|---|---|---|---|
| | | Improved | Check | | | (qtl/ha) | % |
| 1 | Assam | 27.68 | 21.37 | 29.53*** | 10.87 | 16.81 | 60.73 |
| 2 | Uttaranchal | 31.58 | 22.43 | 40.79** | 21.39 | 10.19 | 32.27 |
| 3 | H.P. | 18.18 | 14.65 | 24.10*** | 9.28 | 8.9 | 48.95 |
| 4 | J &K | 27.28 | 24.52 | 11.26*** | 10.03 | 17.25 | 63.23 |
| 5 | U.P. | 42.69 | 38.82 | 9.97*** | 28.46 | 14.23 | 33.33 |
| 6 | W B | 27.87 | 23.35 | 19.36*** | 26.8 | 1.07 | 3.84 |
| 7 | Bihar | 40.37 | 35.45 | 13.88*** | 20.84 | 19.53 | 48.38 |
| 8 | Jharkhand | 35.58 | 29.32 | 21.35*** | 17.38 | 18.2 | 51.15 |
| 9 | Punjab | 47.52 | 43.88 | 8.30*** | 43.07 | 4.45 | 9.36 |
| 10 | Delhi | 43.4 | 40.4 | 7.43*** | 43.52 | -0.12 | -0.28 |
| 11 | Haryana | 49.28 | 47.62 | 3.49*** | 42.13 | 7.15 | 14.51 |
| 12 | Rajasthan | 42.47 | 36.53 | 16.26*** | 31.33 | 11.14 | 26.23 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | Gujarat | 38.85 | 35.3 | 10.06*** | 26.79 | 12.06 | 31.04 |
| 14 | M P | 35.6 | 27.4 | 29.93*** | 19.67 | 15.93 | 44.75 |
| 15 | Chhattisgarh | 32.49 | 24.03 | 35.21*** | 10.86 | 21.63 | 66.57 |
| 16 | Maharashtra | 27.87 | 24.42 | 14.13** | 16.1 | 11.77 | 42.23 |
| 17 | Karnataka | 37.55 | 31.85 | 17.90*** | 8.87 | 28.68 | 76.38 |
| 18 | Tamil Nadu | 31.11 | | | | 31.11 | 100.00 |

* Significant at 10%, ** Significant at 5%,*** Significant at 1%, NS- Not significant

**(3) State-wise Analysis/Difference between FLDs and State Average Yield of Wheat during 2010-11**

| Sl.No. | States | Mean yield (q/ha) | | % Gain | State-wise Av Yield | Gap Between FLDs and State Average Yield | |
|---|---|---|---|---|---|---|---|
| | | Improved | Check | | | (qtl/ha) | % |
| 1 | Assam | 28.8 | 23.09 | 24.73* | 11.79 | 17.01 | 59.06 |
| 2 | Uttaranchal | 33.61 | 25.05 | 34.17** | 23.16 | 10.45 | 31.09 |
| 3 | H P | 31.31 | 25.52 | 22.69*** | 15.3 | 16.01 | 51.13 |
| 4 | J & K | 30.87 | 24.37 | 26.67*** | 15.35 | 15.52 | 50.28 |
| 5 | U P | 45 | 37.96 | 18.54*** | 31.13 | 13.87 | 30.82 |
| 6 | W B | 20.6 | 18.6 | 10.75$^{NS}$ | 27.6 | -7 | -33.98 |
| 7 | Bihar | 41.18 | 36.86 | 11.72*** | 19.48 | 21.7 | 52.70 |
| 8 | Jharkhand | 23.89 | 16.01 | 49.22*** | 16.42 | 7.47 | 31.27 |
| 9 | Punjab | 48.95 | 46.01 | 6.39*** | 46.93 | 2.02 | 4.13 |
| 10 | Delhi | 50.84 | 44.53 | 14.17*** | 43.4 | 7.44 | 14.63 |
| 11 | Haryana | 49.09 | 47.19 | 4.03*** | 46.24 | 2.85 | 5.81 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12 | Rajasthan | 44.51 | 36.32 | 22.55*** | 29.1 | 15.41 | 34.62 |
| 13 | Gujarat | 36.33 | 32.82 | 10.69*** | 31.55 | 4.78 | 13.16 |
| 14 | M P | 42.11 | 32.86 | 28.15*** | 17.57 | 24.54 | 58.28 |
| 15 | Chhattisgarh | 42.11 | 20.71 | 103.33*** | 11.44 | 30.67 | 72.83 |
| 16 | Maharashtra | 34.77 | 30.96 | 12.31*** | 17.61 | 17.16 | 49.35 |
| 17 | Karnataka | 39.51 | 35.01 | 12.85*** | 10.94 | 28.57 | 72.31 |
| 18 | Tamil Nadu | 36.77 | | | | 36.77 | 100.00 |

* Significant at 10%, ** Significant at 5%,*** Significant at 1%, NS- Not significant

**(4) State-wise Analysis/Difference between FLDs and State Average Yield of Wheat during 2011-12**

| Sl.No. | States | Mean yield (q/ha) | | % Gain | State-wise Av Yield | Gap Between FLDs and | |
|---|---|---|---|---|---|---|---|
| | | Improved | Check | | | qtl/ha | % |
| 1 | Assam | 31.3 | 23.1 | 35.50NS | 11.35 | 19.95 | 63.74 |
| 2 | Uttaranchal | 42.96 | 33.28 | 29.09*** | 23.69 | 19.27 | 44.86 |
| 3 | H P | 29.8 | 24.14 | 23.45** | 16.71 | 13.09 | 43.93 |
| 4 | J&K | 31.24 | 26.48 | 17.98*** | 14.04 | 17.2 | 55.06 |
| 5 | UP | 48.44 | 42.56 | 13.82*** | 31.13 | 17.31 | 35.73 |
| 6 | W B | 31.67 | 27.51 | 15.12*** | 28 | 3.67 | 11.59 |
| 7 | Bihar | 43.07 | 37.54 | 14.73*** | 22.06 | 21.01 | 48.78 |
| 8 | Jharkhand | 33.83 | 27.51 | 22.97*** | 18.76 | 15.07 | 44.55 |
| 9 | Punjab | 58.54 | 53.31 | 9.81** | 48.95 | 9.59 | 16.38 |
| 10 | Delhi | 56.38 | 52.57 | 7.86** | | | |
| 11 | Haryana | 59.19 | 55.37 | 6.90*** | 50.3 | 8.89 | 15.02 |
| 12 | Rajasthan | 46.73 | 39.69 | 17.74*** | 31.75 | 14.98 | 32.06 |

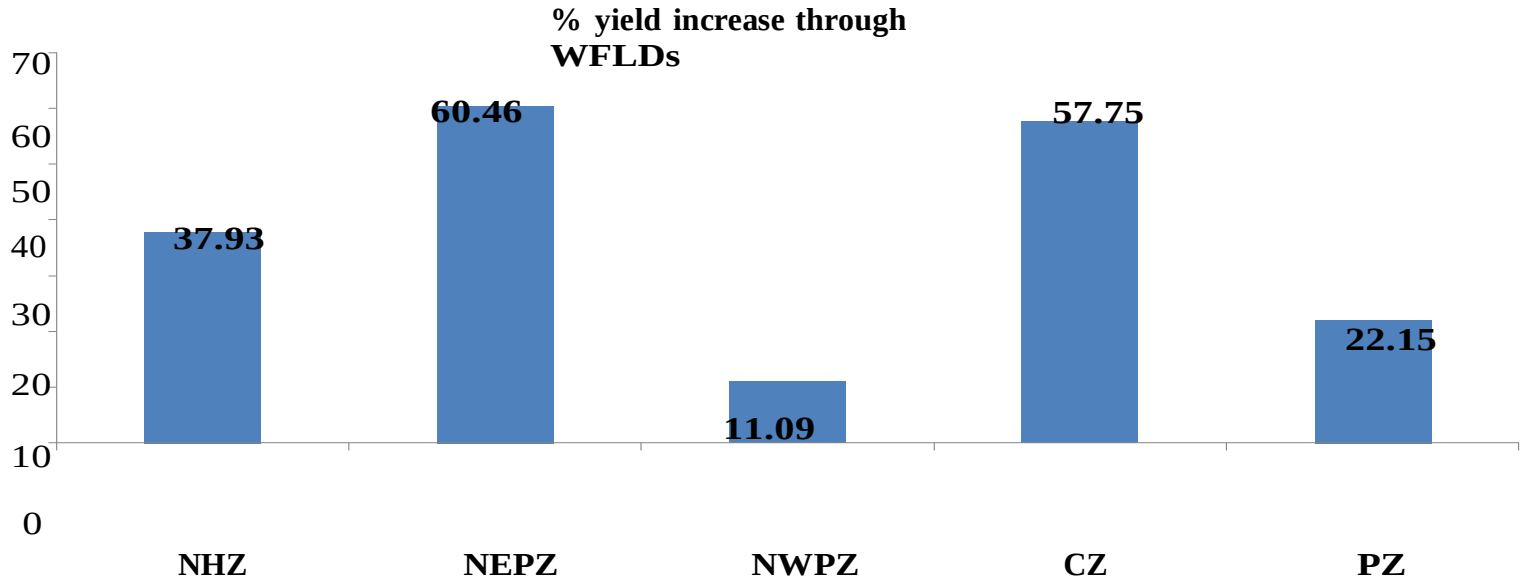
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13 | Gujarat | 40.84 | 36.04 | 13.32* | 30.35 | 10.49 | 25.69 |
| 14 | Madhya Pradesh | 44.9 | 33.39 | 34.47*** | 21.64 | 23.26 | 51.80 |
| 15 | Chhattisgarh | 29.3 | 22.11 | 32.52*** | 11.86 | 17.44 | 59.52 |
| 16 | Maharashtra | 32.96 | 28.9 | 14.05* | 15.58 | 17.38 | 52.73 |
| 17 | Karnataka | 36 | 31.33 | 14.91*** | 8.43 | 27.57 | 76.58 |
| 18 | Tamil Nadu | 36.65 | - | - | | | |

* Significant at 10%, ** Significant at 5%,*** Significant at 1%, NS- Not significant

## Frontline Demonstrations

**•805 WFLDs conducted through 103 coordinating centers, covering 819.87 ha area of 1753 farmers in 18 states.**

**•The maximum number of WFLDs were conducted in UP (115) followed by Haryana (92), Bihar (79), Punjab (61), Rajasthan (54) and Jharkhand (50)**



**Varietal Replacement:** Breeder seed production of high yielding and disease resistant wheat varieties should be promoted and obsolete varieties should be de-notified. The breeder seed production of varieties that need be enhanced are:

**Punjab, Haryana, western UP & Northern Rajasthan :** Since the predominant variety PBW 343 has become susceptible to new yellow rust race (78S84), alternate varieties with adult plant resistance against new race, as noted in DBW 17, are required. .

**Eastern UP, Bihar :** Under timely sown conditions, varieties like HD 2733, HD 2824, PBW 443, and HUW 468 need to be promoted by curtailing UP 262 and HUW 234. Similarly under late sown conditions, varieties like DBW 14, NW 2036, HW 2045, NW 1014, K 8962 and HD 2643should be promoted.

**Intensify Varietal Spread in NEPZ:** In contrast to NWPZ, a large number of genotypes have been notified for the NEPZ but the variety released in 1984 i.e. HUW 234 is still in great demand. The average life of a wheat variety in NEPZ is about 12 years and it is mainly due to poor seed replacement. The northeastern region is catching 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 improved wheat varieties.

**Madhya Pradesh, Chattisgarh, Gujarat and Kota region of Rajasthan :** Lok 1 a reigning variety in central India needs replacement as it is highly susceptible to rusts. GW 322 and GW 273 under timely sown conditions while HD 2864 and MP 4010 under late sown conditions can be the good substitutes. HI 8498 and HI 8381 are the best varieties for durum cultivation in this region. These states have a sizeable rainfed or limited irrigation areas for which HI 1531, HI 1500 of bread wheat and HD 4672 and HI 8627 for durum should be promoted while WH 147 should be phased out.

**Maharashtra and Karnataka :** For timely sown conditions DWR 162, GW 322, NIAW 917, MACS 2496 and RAJ 4037 in bread wheat and MACS 2846 for durum should be promoted. Under late sown conditions PBW 533, HD 2833 and NIAW 34 are recommended. Under rainfed conditions HD 2781,K 9644 for bread wheat and durum wheat variety AKDW 2997-16 should be promoted. New dicoccum varieties namely DDK 1009, DDK 1025 are also good options for the areas under dicoccum cultivation.

**Non-traditional wheat growing areas :** Some areas in Jharkhand, Orissa, West Bengal, Tamil Nadu and Andhra Pradesh should be looked into for increase in the wheat acreage. Suitable varieties falling in that zone need to be tested at farmer's field.

**Source: DWR Vision2025**

**Good Crop Production Technologies**

**Major crop sequences/rotations followed in various states and suggested crop sequence by SAUs/ICAR :-** Rice-vegetable pea-winter maize, rice-wheat-green gram, rice-vegetable pea-wheat for one year rotation and pigeon pea -wheat-rice-wheat and rice-mustard- green gram-rice-wheat for two year rotation. Rice-Wheat, Maize-Wheat, Cotton-Wheat, Soyabean-Wheat, Groundnut-wheat, Tur-Wheat, Urd-Wheat, Jowar/Bajara-Wheat, Sugarcane -Wheat, Rice-Rice-Wheat, Fallow-Wheat, Toria-Wheat,

**Climate requirement:** Wheat crop has wide adaptability. It can be grown not only in the tropical and sub-tropical zones, but also in the temperate zone and the cold tracts of the far north ,beyond even the 60 degree north altitude . Wheat can tolerate severe cold and snow and resume growth with the setting in of warm weather in spring .It can be cultivated from sea level to as high as 3300 meters.

The best wheat are produced in areas favoured with cool, moist weather during the major portion of the growing period followed by dry, warm weather to enable the grain to ripen properly. The optimum temperature range for ideal germination of wheat seed is 20-25 C though the seeds can germinate in the temperature range 3.5 to 35 c. Rains just after sowing hamper germination and encourage seedling blight. Areas with a warm and damp climate are not suited for wheat growing.

During the heading and flowering stages, excessively high or low temperatures and drought are harmful to wheat. Cloudy weather, with high humidity and low temperatures is conducive for rust attack. Wheat plant requires about 14-15 c optimum average temperature at the time of ripening . The temperature conditions at the time of grain filling and development are very crucial for yield. Temperatures above 250c during this period tend to depress grain weight. When temperatures are high, too much energy I lost through the process of transpiration by the plants and the reduced residual energy results in poorer grain formation and lower yields. Wheat is mainly a rabi (winter) season crop in India.

**Soil :** Wheat is grown in a variety of soils of India. Soils with a clay loam or loam texture, good structure and moderate water holding capacity are ideal for wheat cultivation. Care should be taken to avoid very porous and excessively drained oils. Soil should be neutral in its reaction. Heavy soil with good drainage are suitable for wheat cultivation under dry conditions. These soils absorb and retain

rain water well. Heavy soils with poor structure and poor drainage are not suitable as wheat is sensitive to water logging. Wheat can be successfully grown on lighter soils provided their water and nutrient holding capacity are improved.

In India the wheat growing areas can be mainly divided into five soil divisions, viz,1. The Gangetic alluvium of Uttar Pradesh and Bihar,2. The Indus alluvium of the Punjab and Haryana, 3. The black soil regions of central and southern India comprising Madhya Pradesh and parts of Maharashtra and Karnataka, 4. The hilly regions of the Himalaya and elsewhere, and 5. The desert soils of Rajasthan.

1. State and season wise time of sowing and harvesting

| **Name of State** | **Time of Sowing** |
|---|---|
| **Uttar Pradesh** | |
| **Western U.P.** | |
| For Irrigated Conditions | |
| Normal Sowing | 1st Fortnight of Nov. to 15th Nov. |
| Late sowing | 1st to 25th December |
| **Eastern U.P.** | |
| For Irrigated Conditions | |
| Normal Sowing | 1st Fortnight of Nov. to 15th Nov. |
| Late sowing | 1st to 20th December |
| **Bundelkhand Regions** | |
| For Irrigated Conditions | |
| Normal Sowing | 1st Fortnight of Nov. to 15th Nov. |
| Late sowing | 1st to 15th December |
| **Hills** | |
| For Irrigated Conditions – Higher Hills | |
| Normal Sowing | 2nd Fortnight of Oct. to 1st Fortnight of Nov. |
| Late sowing | 1st to 20th December |
| For Irrigated Conditions – Lower Hills | |
| Normal Sowing | Last week of Oct. to middle of Nov. |
| Late sowing | Second fortnight of November |
| **Madhya Pradesh** | |
| For Irrigated Conditions | |

| | |
|---|---|
| Normal Sowing | Whole of Nov. |
| Late sowing | 1st to 15th December |
| **Punjab** | |
| For Irrigated Conditions | |
| Normal Sowing | 1st to 2nd Fortnight of November |
| Late sowing | 1st to 31st December |
| **Rajasthan (whole of Rajasthan except the Kota & Udaipur Divisions)** | |
| For Irrigated Conditions | |
| Normal Sowing | 1st to 2nd Fortnight of November |
| Late sowing | 1st to 25th December |
| **Rajasthan (Kota & Udaipur Divisions only)** | |
| For Irrigated Conditions | |
| Normal Sowing | Whole of November |
| Late sowing | 1st to 15th December |
| **Haryana & Delhi** | |
| For Irrigated Conditions | |
| Normal Sowing (Timely Sowing) | 1st Fortnight to 2nd Fortnight of November |
| Late Sown | 1st to 25th December |
| **Maharashtra** | |
| For Irrigated Conditions | |
| Normal Sowing (Timely Sowing) | November |
| Late Sown | 1st to 10th December |
| **Gujarat** | |
| For Irrigated Conditions | |
| Normal Sowing (Timely Sowing) | November |
| Late Sown | 1st to 15th December |
| **Karnataka** | |
| For Irrigated Conditions | |
| Normal Sowing (Timely Sowing) | November |
| Late Sown | 1st to 15th December |
| **Odisa, West Bengal, Bihar& North East States** | |
| For Irrigated Conditions | |

| | |
|---|---|
| Normal Sowing (Timely Sowing) | 1st Fortnight of November |
| Late Sown | 1st to 15th December |
| **Himachal Pradesh** | |
| For Irrigated Conditions | |
| Higher Hills Normal Sowing (Timely Sowing) | 2nd Fortnight of October to 1st Fortnight of November |
| Lower Hills Normal Sowing (Timely Sowing) | Last week of Oct., to middle of November |
| Late Sowing | 2nd Fortnight of November |
| **Jammu & Kashmir** | |
| For Irrigated Conditions | |
| Kashmir Hills Normal Sowing (Timely Sowing) | 2nd Fortnight of October to middle of November |
| Late Sowing | 2nd Fortnight of November |
| Jammu (Plain Area) Timely owing | 1st Fortnight to 2nd Fortnight of November |
| Late sowing | 1st to 31st of December |
| **Andhra Pradesh** | |
| For Irrigated Conditions | |
| Normal Sowing (Timely Sowing) | November |
| Late Sowing | 1st to 10th December |
| **Tamil Nadu** | |
| For Irrigated Conditions | |
| Early Sowing | October |
| Timely Sowing | November |
| Late Sowing | 1st to 10th December |

**Sowing**

Sowing of crop (i) Different method of sowings : Wheat is sown by four methods:

1. Drilling: In this method seed is sown by seed drill or ferti-seed drill. With the help of this implement seeds drop at uniform depth and results in uniform germination and regular stand. Seed bed should be fine and well leveled free from clods and weeds for the use of seed drill or ferti-seed drill.

2. Behind Local Plough:-This method consist of dropping the seeds by hand into the furrows that have been opened with local plough. When seeds is dropped in furrows by hand, it is called **Kera** method and when it is dropped through a Pora or Nai or Hazara a special attachment with local/desi plough it is called **Pora** method. In this method seeds are dropped at a depth of 5-6 cm and germination is satisfactory.
3. Dibbling: This method is used in case where supply of seed is limited. Sowing is done the help of a small implement known as Dibbler It is a wooden or Iron frame with pegs. The frame is pressed in the field and lifted and then one or two seeds are dropped by hand in each of the hole. It is not a common method because it is a very time consuming process.
4. Broadcast Method: In this method the seeds are broadcast and then worked in by harrowing in order to cover them. However, the seeds are not uniformly distributed in the field. This method of sowing is very insufficient and should not be encouraged. Germination of broadcast seed is relatively oor and the plant stand is often irregular. Wastage of seed also results because most of the seed is left on the surface where they cannot germinate and may, therefore, be picked up and eaten by birds.

(ii) Land preparation by use of different technologies like RCT : As a general rule wheat crop requires a well pulverized but compact seed-bed for good and uniform germination . In irrigated areas wheat is usually sown after Kharif crops like, maize, Jowar, Bajara, Paddy, Urd, Moong(Green gram) etc.. After the harvest of previous crop, the field should be ploughed with disc or mould board plough. Where tractor is available one deep ploughing followed by two or three harrowing with disc or times and 2-3 planking should be given to prepare a well pulverized seed bed. Where bullock are the source of power, deep ploughing followed by two to three harrowings or four to five inter-cross ploughing with local plough should be done. Planking should be done after each ploughing. Avoid powdery seed bed. One pre-sowing irrigation 7-10 days before seeding is necessary to ensure good germination. In case where previous crop was sugarcane, toria, tur etc., the pre- sowing irrigation for wheat may be given in the previous standing crop so that field may become available for its preparation and sowing, soon after the harvest of the previous crop. One light cultivation and leveling is required before sowing. Delay in sowing because drastic reduction in yield in late sown wheat. In certain areas crops are attacked by white ants and gujhia weevil. To protect young seedlings from white ants and gujhia weevil mix Aldrin 5% dust in soil at the rate of 25 kg per ha at the time of ploughing.

In rainfed areas field preparation should be done with great care as conservation of moisture is dependent on it. Field are usually prepared by giving one deep ploughng with iron plough followed by two or three times local plough and planking. In these areas ploughings should be done in the evening time and furrows should be kept open whole night to absorb some moisture from dew.

Planking should be done after each ploughing early in the morning. All the possible efforts should be made to conserve moisture for the sowing of wheat crop.

4.Seeding technologies-time seed rate, distance, depth, plant population :

**Seed :** Selection of Seed : Only healthy seeds of right variety suitable for a particular locality should be selected for sowing. There should not be any mixture of seeds of other varieties of weeds. The seed should be purchased from a reliable source. Always use certified seed . If seed is not treated ,treat with vitavax, thiram @ 2.5 g/kg of seed.

Time of sowing: Time of sowing is one of the important aspects in obtaining good yields of wheat. It has a marked influence on the yield of wheat. The time of sowing varies widely over the wheat growing areas. It depends mostly on soil temperature, irrigation, facilities and duration of wheat varieties. Rainfed wheat generally sown in the $2^{nd}$ fortnight of October and beginning of November. The normal time for sowing of high yielding dwarf varieties in irrigated areas starts in the beginning of November. Long and medium duration varieties should be sown in the $1^{st}$ fortnight of November and short duration varieties should be sown in the $2^{nd}$ fortnight of November. If a variety is sown later than its normal time of sowing there is adverse effect on its yield. Under specific circumstances wheat is sown in the month of December too. In late sown wheat only, short duration varieties should be sown because there is comparatively less reduction in their yields as compared to late and medium duration varieties. When wheat is sown in the month of December there is a drastic reduction in yield( table-1).November onwards delay is sowing by each day causes reduction of 56 kg per
ha per day in north eastern parts of the country and 41.6 kg per day per ha in north-western and central parts of the country.

| Area/Zone | No. of experiments | Date of sowing | | | | Rate of *****reduction in yield/day/ha |
|---|---|---|---|---|---|---|
| | | $1^{st}$ November | $16^{th}$ November | $1^{st}$ December | $16^{th}$ December | |
| North-western plains | 11 | 3650 | 3780 | 3000 | 2551 | 41.6 |
| North-eastern plains | 04 | 4750 | 3670 | 3110 | 2230 | 56.0 |
| Central parts | 06 | 4100 | 4300 | 3750 | 3050 | 41.6 |
| Hilly areas | 02 | 2520 | 1750 | 1800 | 1700 | 18.2 |
| Coastal areas | 02 | 2620 | 2790 | 2340 | 2050 | 24.6 |

**Source: Annual Reports of All India Co-ordinated Wheat Improvement Project 1972-73 & 1973-74.**

*Based on difference in yield of normal sowing and last date of sowing.

Gujarat :- The state Deptt. of Agriculture has reported that because of extremely high temperature on either ends of the season with narrow temperature growing window that most appropriate time of sowing for maximum yields was found to be 15-25$^{th}$ November. Seedling earlier or later than this stipulated period resulted diminution in yield (17-38%) as well as quality of wheat. However, the wheat can be grown till 10$^{th}$ December after which the crop become uneconomical.

Seed rate & spacing: Seed rate varies with variety used depending upon its seed size, germination percentage, tillering ability, time of sowing, moisture content in the soil at the time of sowing and method of sowing. Usually, a seed rate of 100 kg per ha is sufficient under favourable conditions of normal sowing. For varieties with bold grains like Sonalika and under late sown conditions, seed rate should be increased to 125 kg per ha .In case where wheat is to be sown by dibber, a seed rate of 25-30 kg per ha is sufficient.

For normal sown crop a spacing of 20-22.5 Cm between rows is recommended. When sowing is delayed a closer spacing of 15-18 Cm should be adopted.

Depth of sowing:- Depth of sowing is a very important aspect in successful cultivation of high yielding dwarf varieties of wheat. The coleoptile length of high yielding Mexican dwarf varieties is about 5 cm. Therefore, seeds of these varieties should be covered not by more than 5 cm oil to ensure uniform and good germination. Seeds of semi-dwarf (one gene dwarf) varieties could be sown at the depth of 5-6 cm but seeds of three dwarf varieties should not be sown deeper than 4 cm. similarly, in late sown crop, seed should be sown shallow (about 4 cm deep)as deep sowing delays the emergence of seedlings by 2-3 days and heading by 5-6 days.

Source: Modern Techniques of Raising Field Crops- Chhidda Singh

## Resource Management

### Sowing time

The average temperature at sowing : around 23 $1^0C$

**Timely sown :** $5^{th}$ to$11^{th}$ Nov. **; Late sown :** $10^{th}$ to $16^{th}$ Dec.

### Seed Rate:

timely sown conditions : 100 kg/ha

late and rainfed conditions : 125 Kg/ha (increased by 25%)

### Sowing methods:

2. In lines using fertilizers-cum-seed drills and discourage broadcast sowing
3. Row to row spacing : 23cm (timely sown) and 18 cm (late sown)
4. Seeding depth : around 4-5 cm.
5. Zero till and rotary till drill can be used for economising cost of cultivation.

***Use of rotary tiller followed by broadcasting of seed and fertilizer causes the lodging problem leading to reduced yields. Thus, Rotary tiller having drilling mechanism for seed and fertilizer should only be used.***

5.Fertilizer Management: recommended doses for different ecologies, major nutrients organic manures, application method

### Fertilizer management

The time and placement of fertilizer is another area where significant progress was made. It was demonstrated that 120 kg nitrogen, 60 kg phosphorus and 30 kg potash per hectare were required for optimum productivity. The N was to be applied in two split doses of 60 kg as basal and the remaining 60 kg at first irrigation and full phosphorus and potash to be applied as basal. Recently, the new wheat varieties have responded up to 180 kg N/ha with optima dose around 150 kg/ha. In the Indo-Gangetic plains, application of zinc @ 25kg/ha in rice-wheat system was found to increase the yield substantially. Recently, the use of sulphur has been found beneficial for enhancing the productivity as well as the grain protein content of wheat. Response to Mn (pockets in the Indo-Gangetic plains) and boron (eastern and far eastern region) has also been realized.

**Nutrient management**

With intensive agriculture, deficiency of essential nutrients has also become wide spread. The work conducted under the All India Coordinated Research Project on Micronutrient in Crops and Soils, has shown wide spread deficiency of zinc in soils in India. At the national level, the deficiency level in micro nutrients is Zn: 46 %, B: 17 %, Mo: 12 %, Fe: 11 % and Cu: 5%. The deficiency of sulphur has also been reported across a wide range of soils (38%).The yield response to sulphur has been obtained in more than 40 crops including cereal, millets, oilseeds and pulses *etc*. To realize the potential yield, strategies may include:

• Site specific nutrient management for targeted yields
• Integration of crop residues, bio fertilizers etc with inorganic fertilization
• Tillage techniques like FIRBS for increasing nutrient use efficiencies
• Remote sensing for efficient N management
• Nutrient management, straw quality vis-à-vis human and animal health

**Source: DWR Perspective Plan Vision 2025**

## Nutrient management

- Use of recommended doses of the fertilizers (NPK)
- Nitrogen use efficiency is more when fertilizer is placed by drill
- 1/3rd N application at sowing and 2/3rd at first node stage.
- Supplementing inorganic fertilization (NPK) with Zn and FYM increases the wheat yield.
- Application of K is necessary.
- Micronutrient deficiency appears under light soils under intensive cropping especially in rice-wheat cropping system.
    - In sulfur deficient soils, SSP, Cosavet -90 WDG (10 kg/ha) or gypsum (250 kg/ha) can be applied. : increasing yield and protein content.
    - Zinc sulphate should be applied @ 25kg/ha once in rice-wheat system or 2-3 foliar spray of 0.5% zinc sulphate (21% zinc) at 15DI
    - In Mn deficient soil, spray 0.5% managanese sulphate solution 2-4 days before first irrigation and two to three sprays afterwards at weekly intervals on clear sunny day.

### Nutrient Management

| Zones | Sowing Conditions | Time of application |
|---|---|---|
| NWPZ & NEPZ | Irrigated timely sown | 150:60:40 Kg NPK /ha<br>1/3 N+P+K at sowing time and 2/3 at 1st node stage i.e. 35-40 DAS |
| | Irrigated late sown | 120:60:40 Kg NPK /ha<br>1/3 N+P+K at sowing time and 2/3 at 1st node stage i.e. 35-40 DAS |
| | Rainfed | 60:30:20 Kg NPK /ha<br>at time of sowing |
| NHZ,CZ,PZ & SHZ | Irrigated timely sown | 120:60:40 Kg NPK /ha<br>1/3 N+P+K at sowing time and 2/3 at 1st node stage i.e. 35-40 DAS |
| | Irrigated late sown | 90:60:40 Kg NPK /ha<br>1/3 N+P+K at sowing time and 2/3 at 1st node stage i.e. 35-40 DAS |
| | Rainfed | 60:30:20 Kg NPK /ha<br>at time of sowing |

Source-DWR

Manures & fertilizer: Manures and fertilizers both play important roles in wheat cultivation. Use of manure improves the general physical condition and structure of the soil and its capacity to hold water. A liberal quantity of bulky manure should be applied in the field available. About 10 to 15 tons of well rotted FYM or compost should be applied 4 to 6 weeks before sowing and worked well into the soil. However manures by themselves can not meet ,the high nutrient requirements of plant, which are also in shot supply. It, therefore ,becomes necessary to supplement manures with chemical fertilizers to get high yields. The high yielding dwarf varieties of fully exhibit their yield potential only when supplied with adequate quantities of nutrients at proper time. A crop of wheat yielding 50 quintals of grain per ha. Removes 100 to 150 kg nitrogen, 70 to 80 kg phosphorus and 125 to 150 kg potash from the soil. The response of a given variety of wheat to application of fertilizer, however ,varies from field to field and from locality to locality.

Our soils universally deficient in nitrogen but the status of phosphorus and potassium differs from place to place depending on native nutrients store and previous fertilization history of the field. Fertilizer dose for wheat should, therefore, be related to the fertility status
of the soil as indicated by soil tests. In case soil testes recommendations are not available the general guideline for fertilization of high yielding dwarf varieties grown under different agro-climatic conditions laid down by the all India coordinated wheat improvement project should be followed.

These are given here under in table:

Fertilizers recommendations for wheat in different agro-climatic regions

| Conditions | Zone | Recommended dose of NPK(Kg/ha) | | | Time & method of application |
|---|---|---|---|---|---|
| | | N | P2O5 | K2O | |
| Irrigated timely sown | All Zones | 120 | 40 | 00 | Half of N & full quantity of P2O5 should be drilled about 5 Cm below the seed at the time of sowings. The remaining half of N should be top dressed at 1st irrigation. |
| Irrigated late sown | All Zones | 80 | 30-40 | 00 | Half of N& full quantity of P&K should be drilled about 5 Cm below the seed at the time of sowings. The remaining half of N should be top dressed at 1st irrigation. |

| | | | | | |
|---|---|---|---|---|---|
| Irrigated followed by a legume crop or fallow in kharif | All Zones | 80 | 40 | 00 | Half of N& full quantity of P&K should be drilled about 5 Cm below the seed at the time of sowings. The remaining half of N should be top dressed at 1st irrigation. |
| Rainfed | Peninsular & Central Zones | 30 | 20 | 00 | Total quantity of N and P should be applied 8-10 Cm deep in soil at or before sowing. |
| | Other Zones | 40 | 30 | 00 | Total quantity of N and P should be applied 8-10 Cm deep in soil at or before sowing. |

Source: Modern Techniques of Raising Field Crops- Chhidda Singh

6.Water Management : application & conservation methods ,their water use efficiency ,water requirement of crop, critical stages for irrigation and probable losses if not applied : Adequate soil moisture is required for normal development of the wheat plant at all the stages of growth. The crow root initiation stage and heading stage are crucial stages when plant suffers most due to moisture stress .

The following schedule of irrigation should be followed for dwarf varieties of wheat: In case of dwarf high yielding varieties ,a pre-sowing irrigation should be given and crop sown when the field becomes fit for operation.

1st irrigation: The 1st irrigation to the standing crop should be given 20-25 DAS(CRI stage). In cooler regions like hilly tracts and in late sown wheat ,it is desirable to apply 1s irrigation approximately 25-30 DAS. Delay in giving this irrigation should be avoided as it would result in upsetting the synchronous tillering in dwarf high yielding wheat varieties, abnormal heads, poor root system and finally poor grain yield. It is the most crucial stage for irrigation.

2nd Irrigation: At tillering stage, within 40-45 DAS.

3rd irrigation: At late jointing stage , within 70-75 DAS.

4th irrigation: At flowering stage ,within 90-95 DAS. Irrigation at this stage is also important because during this period plants suffer most from soil moisture deficiency . The grain number and grain size are reduced considerable.

5th irrigation: At dough stage, within 110-115 DAS.

The total number o irrigations required will very depending upon soil type, winter rainfall, amount of water applied per irrigation. Under limited supply of water the following schedule of irrigation should be adopted for best utilization of available quantity of water.

1. Where only one irrigation is possible, give it at crown root initiation (CRI) stage (20-25 DAS).
2. Where two irrigations are available, 1st irrigation should be given at CRI stage and 2nd at flowering stage.
3. Where three irrigations are a possible, 1st irrigation should be given at CRI stage and 2nd at lte jointing (boot) and 3rd at milking stage.

These recommendations strongly stress the importance of irrigation at CRI stage. It has been found that each week delay in 1st irrigation from CRI stage results in yield reduction of 200-300 kg per hectare.

Area under irrigated wheat has increased with popularization of the Mexican wheat. At present, nearly 95% of the area sown to wheat in Punjab and Haryana has assured irrigation. The agronomy group has demonstrated that irrigating wheat at crown root initiation stage (CRI) which is approximately 21days after sowing is most crucial. If water is available subsequently, it was advised to utilize the irrigation during tillering and at flowering stages. Using the FIRB technology, it had been demonstrated that water saving to the extent of about 30 percent could be achieved for wheat cultivation.

**Source-DWR**

7. Weed Management :important weed flora, herbicides recommended with doses, application time , and different methods(mechanical & biological etc.)

**Weed management**

Among biotic stresses, weeds play an important role in deciding productivity of any crop. Unfortunately, they are more resistant to abiotic stresses and their nutrient absorption capacity is also better than the wheat crop. In the past, weed control measures were developed in individual crops and very little work has been done to control weeds in a cropping sequence. Therefore, there is a need to focus on integrated weed management and succession of weeds in a cropping sequence. Besides, physical, cultural and chemical means, biological weed control in wheat crop using plant pathogens, especially in the form of myco-herbicides needs to be focused in future. If the rate of current use of herbicide continues, then in future we have to be cautious about ground water contamination, food safety, health hazards, protection of endangered species and herbicide resistant weeds. Therefore, an understanding of weed succession and weed dynamics in relation to various cropping systems, agro-techniques, soil and climate of the agro-ecological system is essential and need following strategies.

• Evaluation of alternate herbicides and herbicide mixtures for resistance inactivation
• Molecular basis of herbicide resistance and identification of markers
• Improving the efficiency of herbicides by using adjuvant /surfactants/proper spray techniques/synergistic herbicide mixtures
• Integration of effective non-chemical measures like competitive varieties, crop rotations, tillage practices, residue retention, etc. with chemical measures
• Exploiting the feasibility of biological control, *i.e.* mycoherbicides
• Studies on weed succession and weed dynamics in relation to various cropping systems and tillage techniques.
• Studies on chemical weed control for companion and intercropping systems
• Identifying the possibility of allele-pathic wheat cultivars for weed management
• Studies on weed biology for the efficient weed management

Weeds emerge with the emerging crop seedlings and if not controlled in the early stages of crop growth these may cause reduction in yield varying from 10-40 % depending upon the intensity and kind of weeds present in an area.When field is generally infested from both dicot and monocot weeds . The major dicot weeds are Chenopodium album, Fumaria purviflora,Cirsium arvense Anagalis arvensis , Melilotus alba, and Melilotus indica,Vicia sativa, , lathyrus spp.,etc., Monocot weeds include: Phalaris minor, Avena fatua, , Polypogon monspllensis, Cyperus rotundus and Cynodon dactylon.

Generally weeds are eradicated with the help of hoe, khurpi etc. However, now-a-days it has become difficult due to labour cost and unavailability of labour. Now a number of chemical weedicides are available that control the weeds in wheat rather effectively. Most common and effective herbicide to kill all the broad leaved weeds in wheat field is 2,4-D. It is available in market under different trade names and each formulation has different amount of active ingredients.

2,4-D should be sprayed in wheat fields 32-35 DAS. This period may be extended to the maximum by one week. But after 40

days of sowing, spray of 2,4-D is not beneficial because by that time weeds have already done the damage to the crop, secondly ,after
40 days weeds become woody in nature and are not likely to be killed easily with the recommended dose of 2,4-D. When 2,4-D is sprayed between 25-30 days , the ears of wheat have been found to suffer from malformation. Malformation adversely affects the uniformly of seed size and thereby reduces their value as grain and seed. Gappy spikelet result in reduction in total number of grains per head and finally lead to reduced grain yield. While spraying 2,4-D avoid drift of spray in the adjoining crop fields, because a slight drift of 2,4-D may spoil the pulses crop like pea, gram, lentil and mustard. It is desirable to spray 2,4-D when wind velocity is minimum.

To control Phalaris minor spray Tribunil or Isoproturon at the rate of 2kg per ha in 400-600 l of water 32-35 DAS . Spray of Isoproturon will also control wild oat if it is present in wheat field.

Source: Modern Techniques of Raising Field Crops- Chhidda Singh

The pre-dominant weeds associated with wheat crop are Anagallis arvensis (Krishananeel), Argemone mexicana (Satyanashi), Asphodelus tenuifolius (Piazi), Avena ludoviciana (Jangli Jai), Cannabis sativa (Bhang), Carthamus oxycantha (Pohli), Chenopodium album (Bathu), Cirsium arvense (Kateli), Convolvulus arvensis (Hirankhuri), Cornopus didymus (Pitpapra), Euphorbia jelioscopia (Dudhi), Fumaria parviflora (Gajri), Lathyrus aphaca (Matri), Malva parviflora (Gogisag), Medicago denticulata (Maina), Malilotus alba (Metha), Phalaris minor(Mandushi/Gulidanda), Poa annua (Poa ghas), Polygonum plebejum (Raniphul), Polypogon monspeliensis (Lomar ghas), Rumex retroflex (Jangli palak), Spergula arvensis (Bandhania), Vicia sativa (Chatri/Gegla).

Phalaris minor is the major weed of wheat in rice wheat system. Sometimes its population is so high (2000-3000 plants / m2) that farmers are forced to harvest the wheat crop as fodder. Isoproturon (Arelon) was recommended for the control of Phalaris minor in 1980s. It remained effective for almost a decade. However, sole dependence on this herbicide resulted in the development of resistance to Isoproturon in Phalaris minor.

In zero tillage fields, the intensity of Rumex and Malwa parviflora is increasing and may become a problem in the coming years. Therefore, we must remain vigilant regarding weed flora shift due to changes in tillage practices.

## Weed Management Practices in Wheat

Various practices of weed management can be grouped into three broad categories namely cultural and preventive; physical or mechanical; and chemical weed control. These practices are discussed below;

### Cultural and Preventive

Cultural practices such as time and method of sowing, crop density and geometry, crop varieties, dose, method and time of fertilizer application, time and method of irrigation have pronounced effect on crop-weed interference. Some of these factors are listed below: Use clean wheat seed that is free from weed seeds. Go in for early sowing of wheat (before 15 Nov.).Adopt closer row spacing (18 cm).Adopt criss-cross sowing to increase population density of the wheat plants. Place basal dose of fertilizer 2-3 cm below the seed. Sowing of wheat on FIRBS reduces weed population. Pull out weeds before seed setting. Keep blinds & irrigation channels free from weeds. Introduce either berseem or oat for fodder, as a crop rotation, sown once in three years. Stimulate emergence of Phalaris by giving light irrigation followed by weed control with non-selective herbicides like glyphosate or cultivation followed by sowing of wheat. Zero tillage offer a way to manage Phalaris but continuously practising zero tillage invites problem from other weeds. Grow fast growing and robust varieties of wheat.

### Mechanical Control

It involves the removal of weeds by various tools & implements including hand weeding & pulling. It is not feasible where weeds resemble morphologically to crop ego P. minor & Avena ludoviciana before flowering in wheat. Also, mechanical weed control becomes difficult in broadcast sown wheat. However, mechanical control can be practiced effectively when wheat is sown on FIRBS as this system facilitates tractor mounted implements usage.

## Chemical Control

Chemical weed control is preferred because of less labor involvement and no mechanical damage to the crop that happens during manual weeding. Moreover, the control is more effective as the weeds even within the rows are killed which invariably escape, because of morphological similarity to wheat, during mechanical control. The following weedicide schedule has been found effective in controlling the Isoproturon resistant population of Phalaris minor.

### Pre-emergence

As pre-emergence, only Stomp 30EC (Pendimethalin) is available which can be applied @ 3300 ml/ha (1000 g a.i/ha) at 0-3 days after sowing in 500 liters of water /ha. Care must be taken to have fine tilth for better performance of pendimethalin. It controls both grasses and broadleaved weeds.

### Post-emergence

During the last 3-4 years a number of herbicides were found effective against even the resistant biotypes of Phalaris minor. Out of the four new herbicides found effective against Phalaris, two namely Sulfosulfuran and Metribuzin were effective against both grassy and non-grassy weeds, whereas clodinafop and fenoxaprop were specific to grassy weeds. Application of Metribuzin should be done carefully as this chemical is not safe at double the recommended dose. Also its application is risky if hot and windy weather prevails and rainfall occurs immediately after its spray / application.

The herbicides that are to be applied as post emergence after first irrigation at 30-35 days of sowing or 2-3 leaf stage of Phalaris minor are;

**Both Grassy and Broad Leaved**

1. Sulfosulfuran @ 25.0g a.i./ha in 250-300 liters of water /ha.
2. Metribuzin @ 175 g a.i./ha in at least 500 liters of water /ha.
3. A mixture of Sulfosulfuran at 25g/ha and metsulfuron methyl @ 4 g/ha in 250-300 liters water /ha.
4. Combination of 2,4-0 and isoproturon can also be used for the control of mixed weed population in resistance free area.

**Only Grassy Weeds**

1. Clodinafop @ 400 g/ha (60g a.i./ha) in 250-300 liters of water / ha.
2. Fenoxaprop-ethyl @ 80-120g a.i./ha in 250-300 liters of water / ha.

**Only Broadleaf Weeds**

1. 2,4-0 @ 500 g a.i./ha in 250-300 liters of water /ha.
2. Metsulfuron methyl @ 4 g a.i. / ha 250-300 liters of water /ha.

Some Useful Hints

**Do's**

Spray the herbicides, both pre and post emergence, when there is sufficient moisture in the soil.

Spray the post-emergence herbicides when Phalaris minor is at 2-3 leaf stage. Spray on clear and sunny days only when the leaves are dry.

Use only flat fan nozzle especially for Fenoxaprop.

Remove Phalaris minor before seed setting and use as fodder. Ensure complete coverage of the field.

**Don'ts**

Do not use Sulfosulfuran in mixed cropping system of wheat and mustard or other crops. Never apply these post emergence herbicides by mixing with sand, urea or soil.

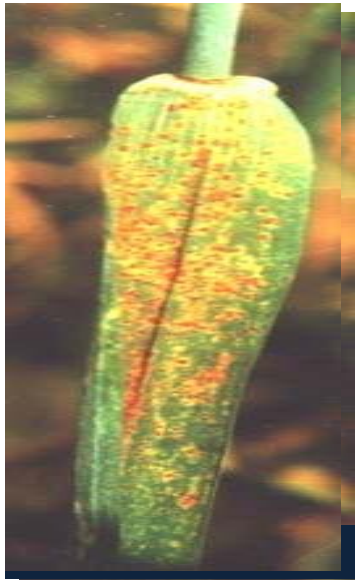
Do not mix Clodinafop and Fenoxaprop with 2,4-D

**8.Plant Protection-Important insect-pests and diseases and their effect on yield loss, chemical biological and cultural control measures**

**Major Issues : Crop Protection**

- Survey and surveillance for monitoring diseases and insect-pest
- IPM in wheat specially to manage the diseases like Karnal Bunt, Powdery Mildew, loose smut and insects like foliar & root aphids, termites, root nematodes
- Managing new emerging threats
  - o stem rust (Ug99),
  - o leaf rust (77-5, 77-10, 104-2)
  - o stripe rust (78S84, 46S119)
  - o Foliar blight
  - o Fusarium head blight (FHB)
- Monitoring dynamics of diseases and insect pest situation in new RCTs and in view of changing climate

**Rust diseases in Wheat**



All Zones


NWPZ &NHZ

Stem /black

CZ, PZ & SHZ

**Major Issues : Resource Management**

- Resource Conservation Technologies
  - Sustaining wheat production & soil health
  - Residue management
- Diversification /intensification of RWCS
  - Farm profitability under rice-wheat system
- Integrated Nutrient Management
  - Balanced use of fertilizers
  - Conjunctive use of inorganic & organic fertilizers
  - Correcting micro-nutrient deficiencies
  - improving C/N ratio
- Integrated Water Management for increasing WUE
  - Water harvesting (storage of rain water)
  - Genotypes with less water requirement
- Integrated Weed Management
  - Herbicide resistance
  - Weed dynamics
- Farm Machineries
  - Fine tuning

**Soil health**

As a consequence of intensive farming, new pest problems are being encountered. The insects survive on the harvested rice stubbles or migrate from the adjoining crop of rice. It is therefore, necessary to develop a technique for removing the rice stubbles and other crop residue to avoid pest build up. There is a need for a continuous monitoring of this pest over NWPZ and NEPZ and understand the insect ecology better. In view of the environment friendly control measures, neem products and *Pasteuria* etc. can also be synthesized for the control of nematodes.

**Major Diseases & Insect-Pests**

Wheat crop suffers from several diseases which reduce its yield and quality. The major diseases of wheat in India are, three rusts - leaf, yellow and stem rust, Karnal bunt, foliar blights, powdery mildew and loose smut. Diseases of limited importance include head scab, foot rot and flag smut; these diseases though of lesser importance, may be important in certain pockets.

**Leaf Rust /Brown Rust(** *Puccinia recondita tritici.)*

**Distribution:** Throughout wheat growing regions of India.

**Development**: Pathogen over-summers in low and mid altitudes of Himalayas and Nilgiris. Primary infections develop fromwind deposited urediospores in eastern Indo-gangetic plains in middle of January where it multiplies and moves westwards by March. Temperatures of 20 :t 5° C with free moisture (rain or dew) cause epidemics. Severe infection causes upto 30 percent yield losses.

**Management:** The presently recommended varieties in most of the wheat growing zones are rust resistant.

**Stripe Rust /Yellow Rust** *(Puccinia striiformis tritici)*

**Distribution:** Hills, foothills and plains of north western India and southern hills zone (Nilgiri hills of Tamilnadu).

**Development:** Spreads through air-borne urediospores, when temperature are 1020°C but the spread is checked above 25°c. Pathogen survives in the cool temperatures of hills ( Himalayas and Nilgiris ) and the primary infection takes places by middle of January in the foot hills and sub mountainous parts of north western India. Also, infection comes from across the western border, hence the probability of evolution of new races increases in this area. Yellow rust from Nilgiri hills cannot come out of the zone due to high temperatures in the Peninsular and Central India.

**Management:** Most of the presently recommended varieties are resistant. Major emphasis is on host resistance and cultivation of resistant varieties is the main strategy of management.

**Stem Rust /Black Rust (***Puccinia graminis tritici)*

**Distribution:** Mainly in Peninsular and I Central India, may occur in traces in Northern India too' were the infestation comes late.

**Development:** Develops from air-borne urediospores, needs free moisture and temperature above 20° C for spread. It can cause severe grain losses if infection is early. The pathogen perpetuates in Nilgiri hills during off season and becomes airborne. If Peninsular and Central India experience rainfall during November then epidemics are severe. Late infections cause less damage in north India.

**Management**: The presently recommended varieties in most of the wheat growing zones are rust resistant, hence the old susceptible varieties be avoided.

**Karnal Bunt** *Tilletia indica (=Neovossia indica)*

**Distribution:** Parts of Northern Plains, especially Punjab, parts of northern Haryana, foot hills of J&K and HP., tarai area of Uttranchal, in lesser severity in Rajasthan, Bihar and UP. The states of Gujarat, Maharashtra, Karnataka and several parts of M.P. are free of KB.

**Development:** Seed and soil-borne; infection occurs at flowering by means of soil-borne inoculum. The degree of disease development depends upon the weather conditions prevailing during spike emergence to grain filling stage of crop. If the rains occur during the month of February in north Indian plains (disease - prone areas), the disease is likely to come with higher severity.

**Management:** Among the present day varieties, PBW 502 is resistant while the others show various levels of susceptibility. For management of this disease, one spray of Propiconazole (Tilt 25EC@ 0.1 %) should be given at the time of anthesis. Integration of one spray of propiconazole with one spray of bioagent fungus, *Trichoderma viride* (0.4% suspension) gives almost cent per cent disease control. The bioagent spray should be done before earhead emergence (Crop growth stage 31- 39 on Zadoks scale), followed by the spray of chemical at start of earhead emergence (crop growth stage 41 -49 on Zadoks scale). Two sprays of *T. viride,* at these two critical growth stages also give non chemical control of the disease which is almost similar to one spray of propiconazole. Chemical control should be adopted mostly in seed production plots.

**Black Point (***Alternaria alternate)*

**Development:** Disease causes blackening of embryonic region of the seed (black point), discoloration of area beyond the embryonic region (black discoloration *(Caused by Aalternata, Curvularia lunate, Epicoccum sp., Bipolaris sorokiniana, etc.)* and eye-spot symptom (B. *sorokiniana).* The warm and humid weather at grain filling or near maturity favors this disease.

**Management:** This disease is of minor importance. Only when the disease percentage is high, it causes concern to the trader and the consumer. The discolored seeds are mostly shrivelled and they are separated out during processing.

**Loose Smut** *(Ustilago segatum (U. tritici)*

**Distribution:** North Indian plains and northern hills zone.

**Development:** It is a seed borne disease; infection occurs during *Loose Smut* flowering through wind-borne spores. The infection remains dormant inside the otherwise healthy looking seed but the plants grown from such seeds bear infected inflorescence. Infection is favored by cool, humid conditions during flowering period of the host plant.

**Management:** Disease can be easily controlled through seed treatment with systemic fungicides hence resistance breeding has not attracted much attention. Treat the seed with fungicides like carboxin (Vitavax 75WP @ 2.5g / kg seed), carbendazim (Bavistin 50WP @ 2.5g / kg seed), tebuconazole (Raxil 2DS @ 1.25g / kg seed) if the disease level in the seed lot is high. If it is low to moderate, treat the seed with a combination of *Trichoderma viride* (@4 g/ kg seed) and half the recommended dose of carboxin (Vitavax 75WP @ 1.25g / kg seed).

**Foliar Blights***(Bipolaris sorokiniana* (Spot blotch), *Pyrenophora tritici repentis* (leaf blotch or tan spot), *Alternaria triticina* (Alternaria leaf blight)

**Distribution:** Mainly in eastern India but also occurs in Peninsular and Central *Foliar blights* India. This disease complex is emerging as a problem in the north western India too.

**Development**: The disease requires high temperature and high humidity. This disease is more severe in late sown crop and causes substantial yield losses through formation of shrivelled grains. Most of the varieties are susceptible or moderately susceptible. The disease can be controlled through one spray of propiconazole (Tilt 25EC @ 0.1 %).

**Powdery Mildew** *(Erysiphe graminis tritici)*

**Distribution:** Mainly in the cooler areas and hilly region; foot hills and plains of north - western India and the southern hills (Nilgiris).

**Development:** Powdery mildew can easily be diagnosed by the white, powdery patches that form on the upper surface of leaves and stem. With age, the patches turn dull dirty white and may have small black specks embedded. This disease can spread to all aboveground

parts of the plant, including earhead and awns. The disease infects plants during periods of high humidity (not necessarily rain) and cool to moderate temperatures. Low light intensity, which accompanies dry weather and a dense crop canopy favours this disease.

**Management:** Present day varieties are not resistant to powdery mildew. Hence, the disease severity is more in some pockets. Avoid excessively dense, stands by using adequate seed. For chemical control, one spray of propi-conazole (Tilt 25EC@ 0.1 %) on disease appearance (which usually occurs during early March in northern plains) is highly effective.

**Head Scab** *(Fusarium graminearum)*

**Distribution:** Parts of Punjab, especially in the sub mountainous regions. Bread wheat suffers lesser damage than the durum. It was first recorded in severe proportion in some parts of Punjab during 1995-96 crop season and again during 2004-05 crop season.

**Development**: Disease development is favoured by cool, moist weather with high humidity. Spores are produced on crop debris and reach the leaves through rain splash or wind. Apart from ear head infection, it can cause seedling blight and foot rot leading to lodging. In severe cases, it can cause shriveling of grains and low-test weights. At present, it is a disease of limited importance but has the potential to emerge as a major problem due to the production of toxins.

**Management:** Bread wheat are more resistant than durum. However, no resistant varieties are available. Hence, vigil is needed for this disease.

Source: Krishi Seva . com

| Diseases | Control Measures |
|---|---|
| Karnal Bunt | This is fungal disease. To avoid planting highly susceptible wheat varieties in the Tarai area. Use disease free seeds. Seed borne inoculums can be killed by treating seed with mercury fungicide at the rate of 2.5 g/kg of wheat seed. Avoid continuous cro pping of wheat in the same field. Practices field sanitation and deep ploughing in summer |
| Wheat rusts | Grow rust resistant varieties of wheat recommended for a particular area. It is safer to divide the total farm area for wheat cultivation under 3-4 different varieties of wheat. In other words ,sowing the total area with a single variety is unsafe. Avoid late sowing of late maturing varieties. Late sown crop is more exposed to rust damage. Do not use excess nitrogenous fertilizers as very high nitrogen dose favours rust development. Use of high dose of potash |
| Loose Smut | Growing of loose smut resistant varieties is the best method of control. Since loose smut fungus depends on |

| | |
|---|---|
| | and carry-over from one season to another, growing of disease free seed is the only alternative method of control of available at present<br>for large scale adoptions. Treat the seed with vitavax at the rate of 2.5 g/kg of wheat seed before sowing. At the time of ear emergence<br>,visit the seed crop regularly and locate with diseases ears. Uproot the entire plant while covering the diseased ears with a paper envelop so that black powder do not spread. Destroy it by burying under the |
| Alternaria Leaf Blight | Seed borne inoculums can be killed by treating seed with vitavax at the rate of 2.5 g/kg of seed. Apply adequate fertilizers and<br>irrigations. Alternaria Leaf Blight can also be controlled by zinab or Dithane M-45 sprays. The fungicide may |
| Powdery mildew | Grow varieties resistant to the diseases. Burn crop refuge in the field after harvesting is over. If losses are expected to be high, spraying<br>with a mixture of Dithane M-45 and Karathane has been found beneficial . Prepare mixture by mixing 16 parts of Dithane M-45 and 4 parts of Karathane 25 wettable powder. Spray mixture at the rate of two kg in 1000 litres |

Source: Modern Techniques of Raising Field Crops- Chhidda Singh

Insect Pests: wheat is attacked by a number of insect pests and rodents both in the field and in storage. Some important common ones are here under :

**Cereal Cyst Nematode** *(Heterodera avenae)*

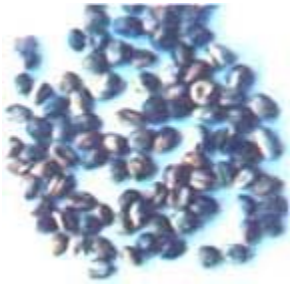
**Distribution :** This nematode is found In most of the cereal growing regions of the country, especially, the

dry and warmer areas of Rajasthan, Haryana and Punjab, but incidence is less in cooler climates.

**Development:** Larvae enter the roots near the growing point especially, at the seedling stage. Roots of infected plants become predisposed to various soil borne disease like root rots. In infected fields, the losses can be considerably enough.

**Management:** Most of the wheat cultivars are susceptible but some resist cyst formation. Chemical pesticides, some natural plant products and botanicals, coupled with improved cultural practices help in management of the CCN. For Rajasthan, one CCN resistant variety, CCNRV - 1 is available for the disease prone areas.

**Seed Gall Nematode** ***/Ear Cockle*** *(Anguina tritici)*



**Distribution:** It is found mainly in some parts of northern India especially the states of Bihar, Jharkhand, eastern UP and Chhatisgarh.

**Development:** These nematodes are spread through seed galls in the seed lots during planting and harvesting. Wet weather favors larval movement and infestation. The nematode invades the crown and basal stem area, finally penetrating floral primordia. This leads to formation of nematode galls in ear heads.

**Management:** Use of clean seed (free of galls) is the only method to prevent this disease. For removal of galls, the seed lots are floated in 2 - 5 per cent brine solution. The galls, which float on the surface, can be easily separated and destroyed away from the fields. The seed thus cleaned should be washed with fresh water and used for planting.

**Aphids** *(Sitobion avenae, Rhopalosiphum padi* and various other species)

**Distribution**: All wheat growing areas, especially in NWPZ and Peninsular India.

**Development**: The aphids exist in different stages, *viz.*, winged (alates), wingless (apterous) sexual and asexual forms. The rapid spread takes place through asexual reproduction where females give rise directly to nymphs rather than eggs. Infestation usually occurs during second fortnight of January till crop maturity.

**Management:** When feeding in sufficient numbers, they can cause considerable damage, but under normal conditions, losses are not much. Chemical pesticides are recommended for this pest in wheat if the level of aphids per tiller crosses 10 during vegetative phase and 5 during reproductive phase. However, there is need to keep watch on this pest. The spray of imidacloprid @ 20 g a.i. per ha initially on border rows and if infestation is severe then in entire field will give good protection against this pest. Generally, natural enemies present in the field help in controlling the population of this pest.

**Brown Wheat Mite** (*Petrobia lateens)*

**Distribution**: In most of the wheat growing areas, under rainfed conditions, especially in the states of Rajasthan, Haryana and M.P. Sometimes, it is a pest in humid and warm conditions of irrigated

areas also.

**Development:** They *Brown wheat* cause damage through *mite infestation*

sucking mouth parts. When present in large numbers, mites cause a silvery flecking on leaves. Individual mites are too small to be visible with naked eye without 'effort. These can be seen by shaking the infested leaves on a white paper.

Management: Most of the times, mites do not cause any production constraint in wheat so no management practices are required. However, there is a need to keep vigil on this pest so that it may not become important in changing cropping sequence of future.

**Army Worm** *(Mythimna separate)*

**Distribution:** Mostly in the warmer climates of central India and to some extent in northern plains.

**Development & Management:** The larvae are found in the cracks of soil and hide during the day but feed during night or early morning. In wet and humid weather, they may feed during day time also. They survive during summer on the subsequent crops like rice and also continue to exist in rice stubbles before wheat crop comes in the field. Recently, this pest is catching attention in the northern India under Rice-Wheat rotation and where rice stubbles / straw remain in the fields.

**Legume Pod-borer** *Helicoverpa armigera* (= *Heliothis armigera):* **Distribution and Importance:** This is a polyphagous insect that attacks various legumes as a pod border. It is seen damaging wheat ear heads at grain development stage when major hosts are not available. However, the damage is below economic threshold level. It is found mostly in northern and central parts of India. Wheat can serve as a bridge host for carry over of this polyphagous pest.

**Termites** *(Odontotermis obesus, Microtermis obesi)*

**Distribution:** Mainly in the northern and central India, but also in some pockets of peninsular India.

**Early Symptoms of Damage:** Termites attack the crop at various growth stages,

from seedlings to maturity. The severely damaged plants can be easily uprooted and look wilted and dried. In case roots are partially damaged, the plants show yellowing.

**Management:** For effective management, chemicals like chlorpyriphos and carbosulfan can be used both for seed treatment and for broadcast of treated soil in standing crop.

**Rodents:** They cause heavy lots to wheat crop and do considerable damage to the harvested crops lying in tacks in the field. For the control of field rats close all burrows in the evening and fumigate the reopened burrows of rats in the morning time with aluminium phoshide at the rate of one tablet of 0.5 g per small burrow and 3.0 g per large burrow. In case of re-appearance in the large fiel, bait with cumarin(ratafin) at the rate of 01 kg of prepared bait (01 part cumari:19 part wheat or maize flour,01 part molasses and 01 part mustard oil).

Source: Modern Techniques of Raising Field Crops- Chhidda Singh

**9. Harvesting , threshing & storage:** harvesting and threshing methods (manual/mechanical), storage-moisture content , drying, chemical used for storage pests.

Harvesting and threshing: High yielding dwarf varieties of wheat should be harvested when the leaves and stems turn yellow and become fairly dry. To avoid loss in yield crop should be harvested before it is dead ripe. when harvest is not done in time, grain may be lost die to damage by rain, birds, insects, shattering and lodging. Timely harvesting ensures optimum grain quality and consumer acceptance. The right stage for harvesting is when there is about 25-30% moisture in grains. Harvesting is normally done with serrate edge sickles by hand. Bullock driven reapers are also used occasionally . Combines are also available which can be harvesting, threshing and winnowing wheat crop in single operation . After harvesting the crop by hand, it is dried and three to four days on the threshing floor and then threshing is done by trampling bullocks or thresher attached to bullocks. Now-a-days power driven stationary threshers are becoming more popular because these are easy in operation and hasten the process.

Source: Modern Techniques of Raising Field Crops- Chhidda Singh

Yield: When cultivation of high yielding dwarf varieties of wheat is done with improved scientific methods, they produce about 45-55 qtl of grain per hectare under irrigated conditions and 20-25 qtl per hectare under rainfed conditions. For safe storage, grain should be cleaned and dried well in sun for a few days so that moisture content of grain comes down to 10-12 percent.

Source: Modern Techniques of Raising Field Crops- Chhidda Singh

**Storage-moisture content , drying, chemical used for storage pests:** For safe storage , grain should be cleaned and dried well in sun for a few days so that moisture content of the grain comes down to 10-12 percent. For safe storage , grain should be cleaned and dried well in sun for a few days so that moisture content of the grain comes down to 8- 10 percent.
Gujarat State: Storage of wheat after due cleaning and drying in sunlight to reduce moisture content to below 10% in clean, insect free galvanized beans after coating of castor oil @ 500ml/qtl of grains or by mixing dry neem leaves @ 2kg/qtl of grains. Store the grain in

galvanized beans and fumigate it with aluminum phosphide @ 01 tablet (3g of each) or EDB @ 3 ml/100 kg of grains.

**Major storage pests :** Major storage pests is placed below:

| S.No. | Major storage pests | Scientific Name |
|---|---|---|
| 1 | Rice Weevil | Sitophilus oryzae |
| 2 | Lesser grain borer | Rhizoperitha dominica |
| 3 | Khapra beetle | Trogoderma granarium |
| 4 | Red Flour Beetle | Tribolium castaneum |
| 5 | Saw-tooshed grain beetle | Oryzaephillus surinamensis |
| 6 | Flat grain beetle | Laemophoesus minutus |
| 7 | Grain moth | Sitotroga cerealella |
| 8 | Rice moth | Corcyra cephalonica |
| 9 | Almond moth | Ephestia cautella |
| 10 | Pulse moth | Callosobruchus chinensis |
| 11 | Cigarette beetle | Lasioderma serricorne |

**Chemical used for storage pests :** For storage :

1. Warehouse should be Pakka , well cleaned and damp-proof.
2. Warehouse : Spray with 0.5% of Malathion solution @3.00 litre of water per sq.m..
3. Old Jute bag may be used and Jute Bag may be kept in boiled water for 15 minutes and dried.
4. Grain mixed with neem seed kernel powder @100 Grain : 01 neem seed kernel powder and then stored.

**Source: Plant Protection-Insect Control-Upadhyay & Mathur, Deptt. of Entomology,CSAU&T,Kanpur**

10. **Use & recommendations of farm implements and machines used for different operations :**

New resource conservation technologies such as zero-tillage was developed and adopted by the farmers of NWPZ & NEPZ or producing wheat at lower cost. The laser land leveling is paying rich dividends in the NWPZ by enhancing input use efficiency and increasing productivity . The other RCTs which can be adopted by the farmers in near future are FIRB, Rotary-Till Drill, Strip Till Drill and Rotary Disc Drill. Adopting conservation Agriculture, i.e., seeding into surface retained residue will help in improving the sustainability of soil & water resource by avoiding crop residue burning leading to healthier environment as well as enhanced productivity with lower external inputs.

**Diversification / intensification of rice-wheat system**: Due to the exhausting nature of rice-wheat cropping sequence ,soil fertility is depending leading to decline in productivity. Diversification / intensification for replacing one or the other crop such options like introducing a short duration legume crop was explored. The alternative cropping system which were more remunerative with accompanying change in tillage options (FIRB) were, rice-vegetable pea-winter maize, rice-wheat-green gram, rice-vegetable pea-wheat for one year rotation and pigeon pea -wheat-rice-wheat and rice-mustard-green gram-rice-wheat for two year rotation.

**DWR Perspective Plan Vision 2025**

Gujarat State- The deptt. of Agriculture, Gujarat has reported that the popular wheat based cropping system are adopted by farmers in the state according to different agro climatic zone are as below:

Rice-wheat (South Gujarat),Pulses (Moong/Urd/cowpea)-wheat (North-middle Gujarat and Saurastra),Cotton-wheat (Whole Gujarat),Sorghum/maize/bajra-wheat & Groundnut/till-wheat (Saurastra region), Sugarcane-wheat (South Gujarat).
Major Crop sequences/rotation followed and suggested crop sequence by ICAR/SAUs in Gujarat State: Profitable one year crop sequence is Cowpea-wheat-Bajra followed by moong-wheat-Bajra whereas groundnut-wheat-cotton-wheat was found profitable for two year crop sequences.
Suggest alternate cropping systems to tackle the soil and water related problem in Gujarat state:

1. Cotton-wheat(with late sown vareties like GW173 & GW11)
2. Rice-wheat (sow wheat with use of zero tillage).
3. Pulses (Moong/Urd/cowpea)-wheat(timely sown wheat varieties should be sown).
4. Sorghum/maize/bajra-wheat(timely sown wheat varieties should be sown).
5. Groundnut/till-wheat (timely sown wheat varieties should be sown).
6. Sugarcane-wheat (timely sown wheat varieties should be sown).

## Crop Products

### i. Industrial use of product and by-product,

Products

**Whole wheat flour**

It contains the finely ground bran, germ and endosperm of the whole kernel. Whole wheat products have a distinctive flavour and coarser texture than those made from white flour

**Maida:**

The bran and germ are separated in making white flour or maida. Maida bakes more uniformly into a loaf of a greater volume and it is more bland in taste and more easily digested. It can be stored in an air-tight container in a refrigerator

**Semolina:**

It is coarsely ground endosperm and its chemical composition is similar to that of white flour. It is used in the manufacture of macaroni products. It is roasted before storing to save it from insects and worms.

**Macaroni products:**

These products are also called pasta or alimentary pastes. These products include macaroni, spaghetti, vermicelli and noodles.

**Wheat germ:**

Wheat germ is about 2-3 per cent of wheat grain. It has a high nutritional quality, comparable to animal proteins.

**Wheat bran:**

It increases the stool weight by increasing the water holding capacity of the bran. Wheat bran prevents constipation and may lower the risk of colon cancer.

## By-Products

We would like to consider using wheat by-products, mainly stalks, for the following products; (1) geotextiles, (2) filters, (3) sorbents, (4) structural composites, (5) non-structural composites, (6) molded products, (7) packaging, and (8) combinations with other materials.

**Wheat is also being utilized in these other products**

**Straw Particle Board (wood)** . Primary uses of strawboard include ready to assemble furniture, flooring a, foundation for lamination and kitchen cabinets.
**Paper Wheat starch makes paper stronger**.
**Adhesives** (Many types) Starch is used as an adhesive on postage stamps and is used to hold the bottom of paper grocery sacks together.

Polymers,Packing peanuts,Plastic Bags,Plastic film, eating utensils and molded items (biodegradable)
Packaging, foams and insulation (biodegradable, starch-based),Reinforcing agents in rubber products (flour-based),Charcoal,Cups,Fine paper products (carbonless copy paper),Fuels,Golf Tees,Insulation
Medical swabs,Roofing and other building materials,Textile finishing agents,Wood substitute in composite building materials

**Cosmetics and Pharmaceutical products** Wheat starch could be substituted in significant volumes for current materials if probed commercially viable.

Hair conditioners, Moisturizers, Liquid laundry detergents, Water-soluble inks

**Starch replacing fat** in desserts Researchers have found when wheat starch replaces fat in frozen desserts, the desserts not only are lower in fat, but also are creamier and tastier than the same product without wheat starch.

**Milk replacers**
Egg white substitutes,Non-dairy products including whipped toppings, creamers
Co-binder in food and non-food packaging,A carrier of the controlled release of pesticides or flavors

**ii. Products derived from main product and by-product and their uses**

**Wheat Food products**

**Generic Type of wheat food products**

| **Hard wheat derived** |
|---|
| White pan breads,White speciality breads,Wheat breads |
| **Wheat-other mixtures** |
| Rye and pumpernickel breads,Mixed grain breads |
| **Soft wheat** |
| Crackers,Cookies,Cakes,Pie crusts,Prezels,Puff pastries,Doughnuts,Refrigerates dough |
| **Durum wheat** |
| Pasta products |
| **Wheat breakfast cereals** |
| Traditional hot cereals,Instant traditional hot cereals,Ready to eat cereals,Micellaneous cereals |

**Traditional products made from different species of wheat**

| **Type of wheat** | **Products** |
|---|---|
| **Bread** | **Chapati/Roti/Phulka,Tandoori Roti,Rumali Roti,Naan,Kulcha,Bhatura,Pizza,Kachori,Samosa,Matthi,Namakpara,Papad,Prantha,Paysam,Balusai,Jalebi,Ghewar,Phirni,Sawainan,Chikki,Vattayappam,Palappam,Shahitoast,Noodles,Laddu,** |
| **Durum** | **Chapati,Paramtha,Dhebra,Bhakri,Porridge,(salted&sweet),RawaIdli,Rawa Puttu,**<br>**KHICH DI etc.** |

| | |
|---|---|
| **Dicoccum** | **Culadi ki Laddu,GodiHuggi,Sweet pan cake,Madal etc.** |

**Processing**

**1. Bakery Flours**

| Bakery Flours | Applications |
|---|---|
| Wheat Flour For Luxury Bread | Premium quality luxury bread making wheat flour with high strength and protein |
| Wheat Flour For Bread | High quality bread making wheat flour with moderate strength and protein content. Suitable for French baguette and all bread types |
| Wheat Flour For Bread | High quality bread and all purpose flour |
| Wheat Flour For Bread | Darker coloured, bread making wheat flour. Suitable for Indian type and flat breads. |
| All Purpose Wheat Flour | A perfect balance of flour strength and cost effectiveness. Suitable for all applications. |
| Wheat Flour For Wet Noodle | High elastic character with low ash content. Specially designed wet noodle. |
| Wheat Flour For Instant Noodle | Lower strength and protein content. Mainly suitable for<br>cake, confectionary and instant noodle. |
| Wheat Flour For Industrial use | Industrial wheat flour for animal feed |
| Wheat Barn | The by product of wheat milling, used in the animal feed |

**2. Specialty Flours**

**Applications**

Bread Mix With Oats,Multi Grain Bread Mix,Bread Mix With Wheat Bran

**3. Feed Products**

Wheat Midds Animal feed ,Wheat Midds Pellets Animal feed, Red Dog Animal feed Wheat Germ Animal vitamins. Second Clear Flour Pet food,animal feed, plywood industry, vital wheat gluten. Durum Second Clear Pet food.

## Wheat Milling Products

**White flour** is the finely ground endosperm of the wheat kernel.

**All-purpose flour** is white flour milled from hard wheats or a blend of hard and soft wheats.

**Bread flour** is white flour that is a blend of hard, high-protein wheats and has greater gluten strength and protein content than all-purpose flour.

**Cake flour** is fine-textured, silky flour milled from soft wheats with low protein content.

**Self-rising flour**, also referred to as phosphated flour, is a convenience product made be adding salt and leavening to all-purpose flour..

**Pastry flour** has properties intermediate between those of all-purpose and cake flours. It is usually milled from soft wheat for pastry-making, but can be used for cookies, cakes, crackers and similar products.

**Semolina** is the coarsely ground endosperm of durum, a hard spring wheat with a high-gluten content and golden color. It is hard, granular and resembles sugar. **Durum flour** is finely ground semolina. It is usually enriched and used to make noodles.

**Whole wheat, stone-ground and graham flour** can be used interchangeably; nutrient values differ minimally. Either grinding the whole-wheat kernel or recombining the white flour, germ and bran that have been separated during milling produces them. Their only differences may be in coarseness and protein content. Insoluble fiber content is higher than in white flours.

**Gluten flour** is usually milled from spring wheat and has a high protein (40-45 percent), low-starch content. It is used primarily for diabetic breads, or mixed with other non-wheat or low-protein wheat flours to produce a stronger dough structure. Gluten flour improves baking quality and produces high-protein gluten bread.

### Wheat Quality

The main emphasis has been in understanding biochemical/genetic basis of grain quality traits and evaluating quality of the entries tested in the coordinated system. Based on several years of quality analyses, several varieties have been identified for different wheat products. Promising varieties have also been identified for individual quality parameters like protein content, sedimentation value, extraction rate, wet/dry gluten, gluten index, beta carotene, iron, zinc, copper and manganese etc., which can be used in the breeding programme for the improvement of wheat quality. The prospects of combining quality with yield components has been critically examined.

**Chapati :** C 306, Raj 3765, HD 2285, PBW 226, PBW 175, PBW 373, K 8027, LOK 1,MACS 6145, K 9107, UP 262, NW 1014, HUW 234, HUW 533, HD 2833,Sujata, HI 1500, HW 2004, DL-788-2, GW 173, GW 273, GW 322, GW 496

**Bread:** HS 240, VL 738, PBW 396, HD 277, HD 2733, NW 2036, LOK 1, GW 173, GW190, GW 496, HI977, HD 2189, HD 2501, DWR 162, DWR 195, PBW 533

**Biscuit:** Sonalika, UP 2425

**Pasta :** PDW 233, WH 896, PBW 34, HI 8498, HD 4672, MACS 2846, Raj 1555,A-9-30-1, DDK 1009, NP 200

The quality requirements for each end-product have been defined and grain hardness, protein content and gluten strength have been noted as key components in wheat quality. Molecular markers associated with gluten strength in durum wheat have been identified using recombinant inbred lines. Micro level tests useful in breeding for evaluating early segregating generations such as solvent retention capacities and sedimentation tests have been developed for improving wheat quality. Germplasm lines with desirable quality traits have been identified and being used in breeding programme. Nap Hal, the unique Indian land race of wheat has been well characterized at molecular and rheological level and registered at National Gene bank for use in biscuit making quality.
A major impact of wheat production technology developed through wheat research in India can be realized by working out the farm area saved for other land uses. During 1965,India was producing 12.3 m t of wheat from an area of 13.4 m ha with the productivity level of 0.91 t / ha but during 2002 we produced 71.8 m t of wheat from an area of only 25.9 m ha. This was possible by increasing the productivity level up to 2.77 t/ha. If there had not been any increase in the productivity after 1965, we would have needed 78 million hectares of area for producing 71.8 m t of wheat. In this way, over 50 m ha of area has been saved due to enhancing the productivity of wheat varieties.

**Wheat for Robust National Economy**

The impact of wheat research can be judged from the fact that the country could produce extra wheat to the tune of 1159 m t till 2003-04 over the base year of 1964-65. The extra wheat so produced has generated extra money equal to 3, 91,152 million of rupees. As a result, the financial position of wheat growers has improved tremendously and an era of prosperity was ushered. Large number of industries providing fertilizers, weedicides, pesticides, agricultural machinery, and seed producing agencies were set up in the country which created new jobs and business opportunities in rural and urban sectors. Above all, it has brought in a sense of self- respect, pride and honour to India and Indian nationals.

**More Income to the Farmers**

Resource conservation and zero tillage technologies have contributed in lowering the input cost. Adding high productivity gains over it have proved instrumental in raising farmer’s income. Adoption of mechanized farming, increase in tractors and tube wells can be rated good indicators of increased income. The cropping system based varieties have increased cropping intensity roping in additional income. The importance of global trade has also been realized by the farmers and there is enough signal of growing interest of industry to involve farming community in contract farming.

**More Wheat and Product Range**

Even though the Indian wheat is traditionally known for *chapati,* there are now varieties suitable for various products like bread, biscuit, semolina, pasta, macaroni, etc. India is rated as the second largest biscuit industry in the world. The millers, fast food parlours, bakers, even the transporters have gained tremendously from efforts in value addition. The process of social and economic development has developed a sense of competitiveness among the people at large and urbanites in particular. These days earning by each and every one in a family has become a way of thinking. This arduous exercise leaves very little time for the working class to get their meals with traditional approach. More and more people are therefore, now going for instant foods. Preference for low calorie foods is slowly developing among the urbanites that are health conscious. Demand for baby foods and pasta products as well as baked foods are on the rise in the cities. Affluent people are finding convenient food as easy source of their daily meals. Therefore, there is a big scope for converting the wheat grain into value addition.

**Wheat Nutrition and Human Health**

There lies good scope of targeting wheat not only for nutrition security but also a commodity to impart good health. *T. dicoccum* has already established itself as a good cereal crop for diabetic patients. Change in bran proportion in flour makes it more suitable for patients with chronic constipation. Wheat being the basic ingredient of daily diets has enough scope to be manipulated for making different instant foods by supplementing with nutrients/ vitamins/ phospholipids etc. to contain various syndromes likes hypertension, diabetes, bone and skin abnormalities. Since a large section of people now prefer local or herbal products to cure various ailments, it may prove quite rewarding to explore the possibilities of any threat or benefits that wheat can cause for human health.

**Quality Improvement**

Improvement of *chapati*, bread and biscuit making quality of bread wheat and pasta making quality of durum wheat, and the nutritional quality are major concerns of breeding wheat varieties. Defining parameters related to quality of each end-use product and understanding the biochemical/molecular basis of quality of these products will help in developing varieties suitable for these products. Identification of molecular markers linked to pasta quality and higher beta-carotene content can help in improving the nutritional quality of durum wheat and thus enhancing the availability of better nutrition for undernourished population. Micro level tests requiring little (<1.0gram) amount of flour will be identified which will be useful for breeders in screening early segregating generations and thus selecting desirable recombinants. Understanding the molecular basis of grain quality will facilitate the use of wheat for all these products and will almost certainly reduce the reliance on chemical improvers. This will enhance our efficiency for monitoring quality traits in wheat in early segregating generations with greater precision and accuracy under the background of high yield and disease resistance. Further, this will enhance our understanding of genes and proteins involved in product making quality which eventually lead to their manipulation for improved quality.

**Product specific varieties**

Varieties specifically bred for product like bread, biscuit, pasta, noodles and chapati etc. will be a key issue in wheat research. Besides developing breeding programme for product specific varieties, it shall be crucial to define areas and situations where such varieties can be better exploited. Given a large geographic area in different agro-climatic regions, concerted efforts in this direction can help in fine tuning the quality improvement programme of the country.

**Nutritional security**

Wheat has tremendous potential for improvement in the protein content and its quality,beta-carotene and micronutrient contents like iron, zinc, copper, manganese, etc. Such an improvement in nutritional properties of wheat can usher nutritional security to a large population that uses wheat as a staple food crop. Bio-fortification and enhanced bioavailability of micronutrients shall become an important part of the quality improvement activities. It shall also be pertinent to demarcate areas, regions or situations that facilitate rich harvest of grain nutrition.

**Interface with industry**

Even though big opportunity lies to convert a sizable quantity of wheat for value addition, the Indian entrepreneurs are found reluctant whereas multinationals have started spinning money immediately after liberalization. It is possible that the established food ufacturers as well as the new aspirants for the trade are not familiar with the need based product development processes. An interface with the industry therefore is so crucial to promote healthy interaction between researchers, industry and planners.

**Wheat nutrition and human health**

There lies good scope of targeting wheat as a commodity for good health. *Triticum dicoccum* has already established itself as a good cereal crop for diabetic patients. Change in bran proportion in flour makes it more suitable for patients with chronic constipation. Wheat being the basic ingredient of daily diets has enough scope to be manipulated for making different instant foods by supplementing with nutrients/vitamins/phospholipids etc. to contain various syndromes likes hypertension, diabetes, bone and skin abnormalities. It may prove quite rewarding to explore possibilities of threats/benefits that wheat can bring in human health.

**Durum quality**

Durum is mainly used for production of pasta products and its quality characteristics like yellow colour and resistant to over cooking i.e.; cooked pasta should maintain good texture, resists surface disintegration, and has firm structure consistency. Most of these characteristics are determined by the quantity and quality of gluten proteins. Strong gluten with high elastic recovery gives greater cooking stability and higher cooked firmness score, whereas pasta made from weak gluten with low elastic recovery is prone to deteriorate rapidly and become soft with overcooking. The gluten strength in turn is governed by the composition of protein subunits. Therefore, assessing the relative importance of glutenin and gliadin alleles and their interactive effects on pasta making quality, followed by the characterization of their corresponding genes are important for durum improvement.

**Uniqueness of the Indian *dicoccum***

India is the only country in the world growing *T. dicoccum* in approximately 50,000 ha area. It is a highly priced commodity as it has nutritional value. This nutritive species of wheat is tall and low yielding, therefore, there is a need to increase its yield potential. It is also needed to protect the collections available in the peninsular India including the new dwarf dicoccum for reasons of commercial interest. Two additional centres for evaluating the yield trials at Coimbatore and Rudrur are to be established. The resistance to leaf rust is another important aspect to be worked upon. The improvement of existing varieties with respect to various quality aspects/traits of importance is of paramount consideration.

**Shift in food needs of urbanites**

The process of social and economic development has developed a sense of competitiveness among the people at large and urbanites in particular. These days earning by each and every one in a family has become a way of thinking. This arduous exercise leaves very little time for the working class to get their meals with traditional approach. More and more people are therefore, now going for instant foods. Preference for low calorie foods is slowly developing among the urbanites that are health conscious. Demand for baby foods and pasta products as well as baked foods are on the rise in the cities. Affluent people are finding convenient food as easy source of their daily meals. Therefore, there is a big scope for converting the wheat grain into value addition.

**Grain trade**

Wheat traditionally looked upon as a crop grown for *chapati*, semolina or *dalia* has been recognized as tasteful commodity for variety of products today. Therefore, commerce driven support for this crop, may be for domestic industry through value addition or grain export to earn foreign currency has to be duly recognized. Even though export driven programme as in Australia, USA or Canada is totally missing in the country, a step forward has been taken by the Directorate to produce an atlas of Indian Wheat that will prove handy to offer choice to the importing nations. The grading pattern and the suggested means to improve the grade of wheat produced

in various parts of the country will also improve quality of the grains selected for trading. PRA (Pest Risk Analysis) to Karnal bunt, a model design to foresee the risks associated in shipping of wheat from destination, will also be useful in grain trade.

## Climate Change

### Global Climate Change

The incidence of *Fusarium* head blight, powdery mildew and leaf blight of wheat that were thought earlier as minor diseases, are increasing tremendously now a days due to global climate change. The changing raining pattern during the wheat cropping season may make wheat vulnerable to these diseases. There are reports that countries that have followed new tillage practices like zero tillage, are facing more problem due to these disease. Under FIRBS, incidence of powdery mildew has been reported more due to change in micro-climate. Thus, there will be an urgent need to keep vigil on head blight, leaf blight and powdery mildew of wheat under changed tillage practices and climate change. In addition to the above the following will be taken care of :

- Narrowing genetic variability
- Fluctuations in wheat prices in international market
- Depleting the ground water table
- Deteriorating soil health and Micronutrient deficiencies
- Change in pest dynamics scenario due to adoption of new RCTs
- Global climatic changes including warming during next decades
- Patent regulated genetic flow
- Population pressure reducing arable area
- Patent regulated genetic flow

### Mitigating the climate change

Based on the climate scenario predicted by the Geophysical Fluid Dynamics Laboratory (GFDL) model, impact of changed climate on wheat production is predicted for various latitude limits for the summer and winter seasons. In the mid to higher latitudes of developed countries, significant increase in area accompanied by crop yield reductions are expected. At lower latitudes with increasing temperature, significant area will become unsuitable for wheat and yield may decline. Increased water requirements may be anticipated in all regions in these latitudes, which will highlight the importance of irrigation management. A net reduction in wheat production is anticipated due to reduction in growth period as a result of increased temperature. It is predicted that with the doubling of CO2, ambient temperature in India would increase by 3oC and will affect both the area and productivity of wheat. So, there will be a need to evaluate the genotype and environment interaction. It is also predicted that due to increase in ambient temperature agro-climatic zones may shift towards the pole about 100 km per degree centigrade rise in average temperature. This may lead to replacement of wheat area by maize or sorghum and spread of durum wheat in NWPZ as they are more tolerant to heat than bread wheat. The following strategies can help in overcoming the effect of climatic changes:

- Identify/develop short duration varieties having tolerance to early and late heat
- Revisit the sowing time and seeding procedures
- Surface residue retention for temperature moderation and water conservation
- Intercropping of tall and short crops to moderate the micro-climate by shading *etc*
- Diversification of the rice-wheat system

## Major issues

- **Yellow rust in PBW 343 and strategies for faster replacement.**
- **Sowing time of wheat**
- **Need of short duration varieties for restricted irrigation**
- **Varieties for rainfed areas of Uttaranchal and J&K**
- **Imbalanced use of fertilizers**
- **Unavailability of quality seeds**
- **Water scarcity due to drought conditions.**
- **Problem of salinity and**
- **Shift in land use from agriculture to constructions.**

***The state-wise strategy plan was discussed and recommendations were made.***

## Major Issues : Wheat Improvement

**Breaking yield barriers**

**Broadening of genetic base of varieties - pre-breeding**

- Through use of winter x spring hybridization
- Use of germplasm from the centre of origin (ICARDA), Chinese germplasm
- New plant type approach
- Use of alien species for biotic and abiotic stresses

- **Exploitation of heterosis for developing hybrids**
  - Based on CMS system

- **Biotechnological interventions**
  - Gene pyramiding
  - Marker aided selection for biotic, abiotic and quality traits
  - Structural and functional genomics

- **Abiotic Stresses –climate change**
  - Heat and drought
  - Salt stress
  - Waterlogging

**Major Issues: Crop Protection**

- **Survey and surveillance** for monitoring diseases and insect-pest
- **IPM in wheat** specially to manage the diseases like KB, PM, LS and insects like foliar & root aphids, termites, root nematodes
- **Managing new emerging threats**
  - stem rust (**Ug99**),
  - leaf rust (77-5, 77-10, 104-2)
  - stripe rust (**78S84,** 46S119)
  - Foliar blight
  - Fusarium head blight (FHB)
- **Monitoring dynamics of diseases and insect pest** situation in new RCTs and in view of changing climate

**Major Issues: Resource Management**

- **Resource Conservation Technologies**
  - **Sustaining wheat production & soil health**
  - **Residue management**
- **Diversification /intensification of RWCS**
  - **Farm profitability under rice-wheat system**
- **Integrated Nutrient Management**
  - **Balanced use of fertilizers**
  - **Conjunctive use of inorganic & organic fertilizers**
  - **Correcting micro-nutrient deficiencies**
  - **improving C/N ratio**
- **Integrated Water Management for increasing WUE**
  - **Water harvesting (storage of rain water)**
  - **Genotypes with less water requirement**
- **Integrated Weed Management**
  - **Herbicide resistance**
  - **Weed dynamics**
- **Farm Machineries**
  - **Fine tuning**

**National and International Linkages**

To create awareness among the farmers about various technologies, linkages are being established with the SAUs, State Departments of Agriculture, Fertilizer Companies, Input Suppliers, Hariyali Kisan Bazar etc. to carry out research. The Directorate of Wheat Research and the AICW&BIP are having active collaborations with following international and national organizations :

**International linkages**

- International Center for Maize and Wheat Improvement (CIMMYT), Mexico
- International Center for Agricultural Research in Dry Areas (ICARDA), Syria
- International Rice Research Institute (IRRI), Philippines
- United States Department of Agriculture (USDA), USA
- Australian Council of International Agricultural Research (ACIAR), Australia
- Indo-Swiss Collaboration in Biotechnology (ISCB)

**National linkages**

- Department of Biotechnology (DBT), Government of India, New Delhi
- Department of Science and Technology (DST), Government of India, New Delhi
- Council of Scientific and Industrial Research (CSIR)
- State Agricultural Universities (SAUs)
- Banaras Hindu University (BHU)
- Other ICAR Institutes

**Second generation problems**

RCTs have a defining role to bring down the production cost. Zero tillage technology has already been adopted by the farmers in the Indo-Gangetic plains and other options like FIRBs, Rotary-Till Drill, and Strip Till Drill *etc*. are under investigations. Under the changed tillage practices, the weed flora and the dynamics of insect-pests are also showing apparent changes. Hence, there will be need of monitoring not only incidences of weeds and diseases but also the soil health aspects. The introduction of mechanical harvesting of wheat and rice under rice-wheat cropping system has necessitated proper *in-situ* residue management. The seeding/transplanting under zero tillage situations with lots of loose residue is warranting to modify existing tillage machines. There is a need to develop new wheat and rice varieties better suited for growing under specific-tillage practices.

**Resource Management**

**Resource conservation technologies and conservation agriculture**

• Zero tillage technology and Rotary tillage for reduced energy usage
• FIRBS for water use optimization and laser leveler
• Residue management through surface retention and/or incorporation

**Diversification/intensification of rice-wheat system**

• Through alternative crops like maize, soybean etc through FIRB technology for increasing water use efficiency
• Introduction of leguminous crops to regain and build up the soil health.
• Green manuring

**Intercropping/companion cropping**

• Wheat with autumn planted sugarcane and potato
• Seeding wheat in ratoon sugarcane

**Weed dynamics and integrated weed management**

• Cultural and chemical means
• Biological control – mycoherbicides
• Studies on weed succession and weed dynamics in relation to various cropping systems, agro-techniques, soil and climate of the agro-ecological system

**Organic farming and micronutrients**

• Long term experiments on use of organics in wheat production
• Studies on effect of micro-nutrients deficiencies on grain and straw quality vis-à-vis human and animal health

**Farming system approach for sustainability**

• Issues of increased input, energy usage and soil health
• Sustainability of rice-wheat system

• Water scarcity & water use efficiency
• Optimization of inputs and maximization of input use efficiency

**Crop Protection Combating cereal rusts**
• Proper deployment of resistance genes in different epidemiological zones
• Tackling new virulence of yellow rust, 78S84 in PBW 343
• Combating Sr31 virulence (Ug99) for stem rust
• Postulation of rust resistant genes and identification of new races

**Tackling leaf blight, Karnal bunt, powdery mildew and head scab**
• Pathogenic and genetic variability studies
• Incorporation of resistance in popular wheat varieties

**Other priority areas ;**
• Bio-agents for disease management (*Trichoderma* spp. and *Pseudomonas fluorescens*)
• Taking care of nematodes, aphids and termites
• Identification of sources of resistance against diseases and insect pests
• Survey and surveillance for disease and insect pests
• IPM : Use of bio-agents and Plant Growth Promoting Rhizobacteria (PGPR)
• Pest risk analysis for important diseases
• Impact of climatic changes on disease spectrum and Pest dynamics in new RCTs

**Strategy for stripe rust :** There is a need to establish a mechanism by which all the west and south east Asian countries are brought under one network for wheat rusts scouting, sharing of knowledge and expertise involving the following points:
• Mapping virulence/ a virulence patterns of yellow rust pathotypes prevailing in the continuum of MEASA countries.
• Preparation of database on past and present varieties of wheat grown in MEASA countries with particular reference to the yellow rust resistance.
• Survey of grasses (collateral hosts) in the countries of concern and explore their potential to support over summering of *P. triiformis*.
• Development of a common strategy to manage yellow rust in MEASA region.

Source: DWR Perspective Plan Vision 2025