Training Manual No. 5

Hands on Training

Coordinated Trial Conduction, Data Recording and Reporting

Edited by :

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FOREWORD

Wheat programme in India has been nurtured by a strong framework laid by the AICW&BIP with several ICAR institutes, State Agricultural Universities (SAU's) and Central Government Organizations. The project has a unique distinction of established linkages with 29 funded and more than 100 voluntary centres spread over wheat areas in different parts of the country. The coordinating system housed at IIWBR has been responsible for streamlining the country's wheat program, which has achieved the position of world's second largest producer of wheat. The seed production and maintenance of more than 467 varieties recommended for different zones and production conditions is also coordinated from ICAR-IIWBR, Karnal. Scientists of all concerned disciplines work together as a team in planning and execution of the various programmes. For a long time a need was being felt to train personals engaged in trial conduction and data recording to improve the quality of data reporting. Keeping this in view it has been planned to conduct a three days hands on training on "Coordinated Trial Conduction and Data Recording and Reporting" during February 3-5, 2020 at ICAR-IIWBR, Karnal. This training covers all aspects of the wheat & barley coordinated trials such as breeding trials, physiological experiments, breeder and nucleus seed production, germplasm evaluation and characterization, disease screening and recording of disease data, agronomical trials of both wheat and barley crops. The training programme is aimed to train new incumbents, both scientific and technical, who have recently joined the AICRP wheat & barley programme. It would also facilitate the trainees to get hands on training for data recording (disease reactions, various ancillary data) correctly and reporting in data booklets.

I am really happy that this training is being organised during this peak period of wheat crop season and hope that this will certainly be a asset to the workers engaged in wheat and barley research. The idea of preparing the manual pertaining to trial constitution, sowing design, data recording etc is a step towards improving the data recording and analysis.

I thank and complement our wheat scientists who have prepared this long demanding manual covering all important aspects of trial conduction and data recording and analysis.

(Gyanendra Pratap Singh)

CONTENTS

Chapter -1

Abbreviations used in wheat coordinated program

Yield	
Rk	Rank
G	Group (First non-significant)
S.E. (M)	Standard error of the means
C.D.	Critical difference
C.V.	Coefficient of variance
Rusts	
Bl	Black or stem rust
Br	Brown or leaf rust
Yl	Yellow or stripe rust
R	Resistant type of pustule
S	Susceptible type of pustule
MS	Moderately susceptible type of pustule
X/MRMS	Mixed type of reaction, i.e., presence of both resistant and susceptible types of pustules
0	No infection
tS	Trace Susceptible response
tR	Trace Resistant response
5S	First figure (5) represents the severity and the later (S) for the type of pustule response
MR	Moderately resistant type of pustules
ACI	Average coefficient of infection
Loose smut (LS)	
F	Free
tS	Susceptible in traces
S	Susceptible
Other diseases (OD)	
KB	Karnal bunt (%)
LB	Leaf blight (severity scoring based on double digit method)
PM	Powdery mildew (scale 0-9)
BP	Black point (%)
Agronomic characters	
Hd.R	Heading range (days)
Hd.M	Heading mean (days)
Mat.R	Maturity range (days)
Mat.M	Maturity mean (days)
Ht.R	Plant height range (cm)
Ht.M	Plant height mean (cm)
Thr.	Threshability; Ey = easy; M=medium; H = hard
Lod.	Lodging percentage
Grain characteristics	

Col.	Colour of the grain: A= amber; W= white; LR= light red; R= red
Tex	Texture; H= hard; SH= semi-hard; so= soft
TGW.R	1000-grains weight Range (g)
TGW.M	1000-grains weight Mean (g)

Other symbols	
C	Check variety
(I)	Identified variety
(d)	Durum
*	Final year test entry
AVT	Advanced Varietal Trial
NIVT	National Initial Varietal Trial
IVT	Initial Varietal Trial
IR	Irrigated
RF	Rainfed
RI	Restricted irrigation
TS	Timely sown
LS	Late sown
ES	Early sown
Q	Entry good in quality traits
M	Entry from MABB
TAS	*Triticum aestivum*
TAD	*Triticum aestivum + T. durum*
TDM	*Triticum durum*
DIC	*Triticum dicoccum*
VLS	Very late sown trial

Zones	
NHZ	Northern Hills Zone
NWPZ	North Western Plains Zone
NEPZ	North Eastern Plains Zone
CZ	Central Zone
PZ	Peninsular Zone
NAT	National Zone – Trial conducted in two or more zones
ZONE	

Reasons for not reporting the data	
LSM	Low site mean
UY	Unrealistic yield
LS	Late sowing
HCV	High coefficient of variation
LCV	Low coefficient of variation
RMT	Rejected by monitoring team
DNR	Data not reported

Chapter -2
Introduction to Indian Wheat Program and Coordinated set-up
B S Tyagi and Gyanendra Singh

Wheat research in India has capitalized a great deal on the national and international linkages as strengthening such bonds had always been a priority right from pre-green revolution era. Achieving the production targets, fulfilling the farmer and consumer demands, keeping the wheat research programme vibrant has been possible by nurturing such collaborations. The introduction and testing of the exotic types was initiated in India by the end of nineteenth century at Kanpur (1880-81), Nagpur (1887), Lyallpur (1901) and Pune (1903-05). By that time (1905), Sir Albert Howard, his wife Gabriel Howard and Abdul Rehman Khan had started work at the Imperial Agricultural Research Institute, Pusa Bihar to harvest gains of pure line theory in wheat. By the same period, wheat improvement work was also started in Ludhiana in Punjab, Powarkheda, Kanpur and Akola. By the middle of 20th century, several new centres started wheat research in the country like Niphad (1928), Shimla (1935), Gurdaspur (1941), Kulu (1945), Mahableshwar (1942), Jullundur (1947), Bhowali, Durgapura and Kalyani (1949) and Indore (1951).

Till the beginning of sixties, wheat improvement work in India was carried by individual breeders. Inter-disciplinary approach in wheat research started in 1935 when Dr. B. P. Pal (breeder from IARI, New Delhi) and Dr. K. C. Mehta (pathologist of Agricultural College, Agra) collaborated in breeding for rust resistance. In the backlash of several black rust epidemics in central and peninsular India (1946-47), the country underwent a major transformation in wheat research and a 'Coordinated Wheat Rust Control Scheme' was sponsored by the Indian Council of Agricultural Research (ICAR) in 1949. Under the scheme, breeding and mycological work was strengthened at Indian Agricultural Research Institute (IARI), New Delhi. The importance of inter-disciplinary and inter-institutional approach was then realized in developing superior wheat varieties and need for multi-location testing was felt. In 1961-62, an inter-disciplinary wheat programme was started in collaboration with several institutes on a voluntary and informal basis. It paved way for establishment of the All India Coordinated Wheat Improvement Project (AICWIP) in 1965 which was further raised to the level of Wheat Project Directorate in 1978 with headquarter located at IARI, New Delhi. When this project shifted from IARI, New Delhi to Karnal, Haryana in 1991 as Directorate of Wheat Research (DWR); barley crop was also added and it was given the name All India Coordinated Wheat and Barley Improvement Project (AICW&BIP).

Launching of the All India Coordinated Wheat Improvement Project (AICWIP): It could be a sheer coincidence that the advent of dwarf wheats and initiation of AICWIP took place simultaneously in India in 1965. Nevertheless, the system so created in form of AICWIP provided a strong platform for working in close collaboration with the Rockfeller Foundation as was desired by Dr. NE Borlaug. Considering the encouraging results obtained from the preliminary trials on dwarf wheats, the Indian Scientists visited Mexico to take on the spot stock of large number of dwarf wheat strains being grown there. In the beginning, the seed of

four varieties namely, Lerma Rojo 64A, Sonora 63, Sonora 64 and Mayo 64 along with 613 advance generation progenies exhibiting segregation for rust resistance, plant height, maturity duration, grain attributes and phenomenon of grain shattering were introduced. After conducting the multilocational field trials, Lerma Rojo 64A and Sonora 64 were released for the first time as dwarf wheats for commercial cultivation in the country. The central government also took a bold decision to import 18000 tons of seed of these varieties from Mexico by putting aside the strong criticism from various corners. Some of the people had expressed apprehensions against the very success of dwarf wheats in view of stiff competition from vigorous weed flora. The possibility of introduction altogether new noxious weeds and deadly diseases alongwith the huge import of seed quantity at a time, the extensive cultivation of dwarf varieties proved successful in harvesting extremely high yields. However, the consumers did not like them because of their red grains and poor *Chapati* making quality. For seeking answer to this drawback, the segregating generations of 613 progenies introduced from Mexico were subjected to rigrous selection by the breeders working at IARI, New Delhi, Punjab Agricultural University (PAU), Ludhiana, Govind Ballabh Pant University of Agriculture & Technology (GBPUA&T), Pantnagar, Government Agriculture College, Kanpur and Chaudhary Charan Singh Hisar Agricultural University (CCSHAU), Hisar. Number of amber seeded genotypes exhibiting rust resistance, semi-dwarf plant type and appropriate maturity duration were developed at these centres for yield evaluations. Based on their yield performance in multilocational coordinated trials and National demonstrations, four amber seeded improvement dwarf varieties namely, Kalyansona, Sonalika, Safed Lerma and *Chhoti* Lerma were released in 1967. The commercial success of these varieties acted like a catalyst which not only brought revolution in the wheat production but also encouraged the breeders to work with more vigour and dedication. Very soon, Kalyansona and Sonalika became most popular varieties among the farmers and both these varieties occupied larger area in the country. The area under wheat was increased from 12.84 million hectares in 1966-67 to ~ 30 million hectare in 2018-19, but the production jumped tremendously from 11.4 million tons to a record height of 101.20 million tons during the corresponding period. In this way, an era of 'Green Revolution' was actually ushered in India. A massive hybridization programme was initiated by Indian breeders involving the dwarf wheat germplasm received from International Centre for Maize and Wheat Research (CIMMYT), Mexico and indigenous cultivars / land races. This strategy of breeding led to develop better wheat varieties year after year to suit to varying production conditions of different wheat growing zones of the country. The wheat production progressively scaled new heights year after year.

We are the second largest wheat producers in the world since 1997, next only to China. We have not only been able to meet our domestic demands and maintain a sizeable buffer stock of around 20 million ton of wheat in the country, but now we are also in a position to export wheat to other countries. This achievement made in India's wheat production had been perhaps the most important and unparalleled in the history of entire developing world as claimed by the late Nobel Laureate and father of dwarf wheat Dr Norman Ernest Borlaug.

Before touching the major contributions made by various disciplines of the coordinated project, it will not be out of place to briefly explain the *modus-operandi* of AICWIP in the country. The

main strength of AICWIP had been its multidisciplinary and multi-locational approach adopted in carrying out comprehensive research in the field of wheat improvement. The multidiscipline are Crop Improvement (Breeding, Genetics & Physiology); Crop Protection (Pathology, Entomology & Nematology); Resource Management (Agronomy & Soil Science), Quality (Cereal Chemistry) and Social Science (Statistics, Extension & Economics).

The overall working of the project is looked after by the Director stationed at the ICAR-Indian Institute of Wheat and Barley Research located at Karnal in Haryana State with the help of discipline-wise Principal Investigators. The zone-wise activities are carried out with the help of six Zonal Coordinators located in the respective zone. On an average, more than 1500 newly developed advance generation bulks are contributed by nearly 31 breeding centres every year for screening against important diseases mainly the rust at hot-spot in form in Initial Plant Pathological Screening Nursery (IPPSN).

The advance bulks contributed by the respective breeders are simultaneously evaluated against proper check varieties in field trails to generate data on their yield potential. Taking into account the yield data and rust resistance, only 500 new bulks out of 1500 are considered for inclusion in the National Initial Varietal Trials (NIVTs) conducted across the zones at multilocations. The NIVTs are, therefore, the entry point for the new genotypes for testing in the coordinated programme. Besides generating data on grain yield, the new bulks are simultaneously screened against diseases in various pathological nurseries and their grain samples are subjected to laboratory analysis for an array of quality parameters. Following the well-defined norms for grain yield, disease resistance and quality parameters, only the qualifying genotypes are considered for promotion from NIVTs to Advance Varietal Trials (AVTs) conducted in each zone. Near about 200 genotypes find place in the AVTs for screening against diseases, quality parameters and yield potential in second year of the coordinated tests. Some norms are again applied for promotion/ retention of qualifying genotypes in the AVTs. In the third year of tests, besides grain yield, diseases and quality, data are also generated on agronomical manipulations. Hardly 60 genotypes reach the third year (final year) tests of the coordinated programme and only few of these are finally identified/ released as varieties. The final year test materials are also subjected to physiological investigations for knowing their response to different abiotic stress like drought, heat, salinity etc.
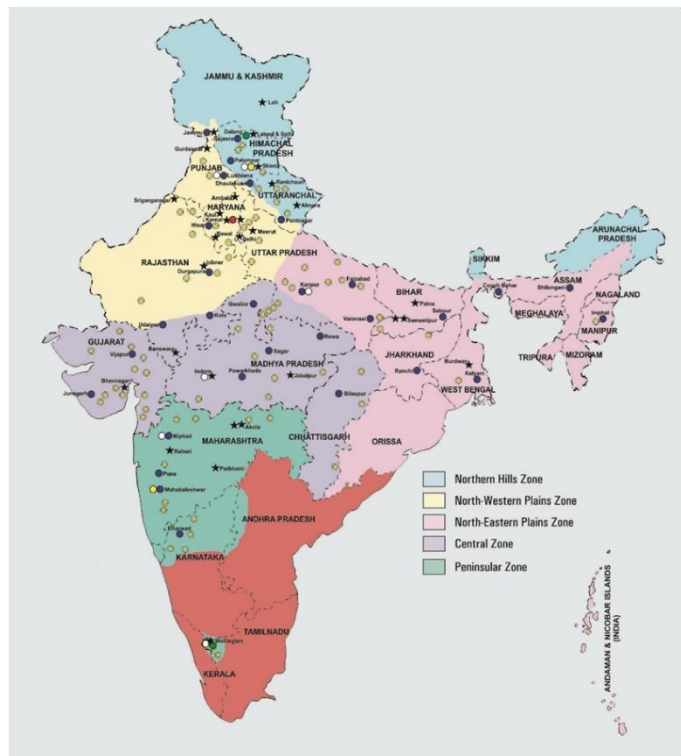
Besides, multidisciplinary and multilocational testing of newly developed genotypes, the coordinated programme also takes care of germplasm evaluation in form of various national and international nurseries for identifying traits specifics donors. From pathological nurseries, donors for disease and pest resistance are identified for utilization in hybridization programme. The survey and surveillance activity is carried out regularly by the Crop Protection scientists help to monitor disease dynamics particularly related to the rust diseases in the country. To fulfil the indents received from different seed agencies, the indented quality of breeder seed of improved wheat varieties is produced by the coordinated centres. Eight hundred and fifty Front Line Demonstrations (FLDs) are laid out in farmers' fields throughout the country by the social scientists for demonstrating the yield potential of newly developed varieties using improved production and protection technologies. The huge data so generated every crop season is properly analysed by the statisticians for preparing discipline-wise annual reports. The multidisciplinary & multilocational results are reviewed in the annul wheat workshop organized every year in the second half of August. Based on collective and common agreement, the technical programme for ensuing crop season is finalized in the workshop. Near about 250 to 300 wheat delegates from India and abroad participate in the annual wheat workshop.

AICWIP TRIALS – Nomenclature
- ✓ IET (Initial Evaluation Trial)
- ✓ URT (Uniform Regional Trial)
- ✓ IVT (Initial Varietal Trial)
- ✓ NYOT (Natl Yield Observation Trial)
- ✓ NIVT (Natl Initial Varietal Trial)
- ✓ AVT (Advance Varietal Trial)
- ✓ Special Trials

Varietal Testing Procedure under AICRP Wheat

One Year Inter Zonal Test		
Trials (NIVTs)	Target Zone	Condition
NIVT-1A and NIVT-1B	NWPZ and NEPZ	Irrigated Timely Sown
NIVT2 and NIVT4 (D)	CZ and PZ	Irrigated Timely Sown
NIVT3A	NWPZ and NEPZ	Irrigated Late Sown
NIVT3B	CZ and PZ	Irrigated Late Sown
NIVT5A	NWPZ, NEPZ, CZ and PZ	Restricted Irrigation Timely Sown
NIVT5B (A+D)	CZ and PZ	Restricted Irrigation Timely Sown
AVT-I (One Year Zonal Test)		
Yield potential, diseases resistance and quality traits are taken into account for retaining entries in AVT-II stage.		
AVT-II (One Year Zonal Test)		
Yield potential, disease resistance, quality traits and agronomical investigations are carried out on final year entries.		

Special trials
Salinity-alkalinity trial, Dicoccum Trial, High Yield Trial

National Initial Varietal Trials and their production conditions along with testing zones

NIVT	Production conditions	Zones
NIVT-1A	Timely sown irrigated high fertility condition (*T. aestivum*)	NWPZ & NEPZ
NIVT-1B	Timely sown irrigated high fertility condition (*T. aestivum*)	NWPZ & NEPZ
NIVT-2	Timely sown irrigated high fertility condition (*T. aestivum*)	CZ & PZ
NIVT-3A	Late sown irrigated medium fertility condition (*T. aestivum*)	NWPZ, NEPZ
NIVT-3B	Late sown irrigated medium fertility condition (*T. aestivum*)	CZ, PZ
NIVT-4	Timely sown irrigated high fertility condition (*T. durum*)	CZ and PZ
NIVT-5A	Timely sown restricted irrigation condition (*T. aestivum*)	NWPZ, NEPZ
NIVT-5B	Timely sown restricted irrigation condition (*T. aestivum* & *T. durum*)	CZ and PZ

Chapter - 3
Constitution of wheat breeding trials under AICRP on wheat and Barley
Satish Kumar and C N Mishra

Constitution of wheat breeding trials is the most important step in the coordination set up. The trials have been specifically designed for each agro-climatic zone. The National Initial Varietal Trials (NIVTs) are constituted at the headquarter, i.e. ICAR – IIWBR, Karnal. The Advance Varietal Trials (AVTs) and special trials are zone specific in nature and hence are constituted at the Zonal Coordinating units for each zone.

The constitution of the trials is the first step in the execution of the annual work plan and hence few specific precautions as listed below, are to be kept in mind:

1) As soon as the annual work plan is finalized (just after the annual group meeting in August), a compiled information in sent to the co-operators by PI – Crop Improvement, requesting the supply of seed for the test entries and the check varieties.

2) The seed of the proposed NIVT entries is to be supplied in required quantity to the PI (Crop Improvement), whereas the seed of the entries to be tested in the AVTs are to be sent to the Zonal Coordinators of each zone. Similarly, the seed of special trials is to be supplied as per the guidance by the PI(CI).

3) The seed is to be supplied in proper sealed bags so as there is no damage during the transport.

4) Once the seed of all the test entries and the checks is received, coding of the trials is initiated. Seed of all the test entries and checks are re-packed in uniform cloth bags and name labels if any are removed from the bags.

5) Also the name tags are kept uniform to avoid any discrepancy.

6) All the wheat breeding trials are double coded i.e. 1st coding and 2nd coding.

7) First coding is got done by persons not directly involved as a contributor of the test entries. Following prefixes are generally used for coding of different trial series:

SN	Trial name*	Proposed code prefix
1	NIVT 1A	N – 101 to N - 136
2	NIVT 1B	N – 201 to N – 236
3	NIVT 2	N – 301 to N – 336
4	NIVT 3A	N – 401 to N – 436
5	NIVT 3B	N – 501 to N – 525
6	NIVT 4	N – 601 to N – 625
7	NIVT 5A	N – 701 to N – 725
8	NIVT 5B	N – 801 to N - 825
9	IVT –RF-TS, NHZ	NHIVT -
10	AVT –RF/IR-TS, NHZ	NHTSZ -
11	AVT –RI-LS, NHZ	NHLSZ -
12	AVT-IR-TS-NWPZ	NW-TS-
13	AVT-IR-LS-NWPZ	NW-LS-
14	AVT-RI-TS-NWPZ	NW-RI-
15	AVT-IR-TS-NEPZ	NE-TS-

16	AVT-IR-LS-NEPZ	NE-LS-
17	AVT-RI-TS-NEPZ	NE-RI-
18	AVT-IR-TS-CZ	CZ-TS-
19	AVT-IR-LS-CZ	CZ-LS-
20	AVT-RI-TS-CZ	CS-RI-
21	AVT-IR-TS-PZ	PZ-TS-
22	AVT-IR-LS-PZ	PZ-LS-
23	AVT-RI-TS-PZ	PS-RI-

* for special trials, prefix SPL- is used before the name of the trial

8) After first coding is done, the seed bags may be arranged in serial so as to avoid any confusion in the second code (since the code names are generally kept same).

9) The second coding is got done by another resource person. The second code is got done on the same day or later on.

10) The first and second codes are signed and sealed by the resource person and submitted to the Director ICAR-IIWBR, Karnal. Decoding of the trials is done once the data received from all the locations is checked and analysed.

11) Once the coding is done, seed samples are taken out for counting thousand grains of each entry, weight of which is used to calculate the amount of seed of each entry to be used in testing.

12) Following formula are used to calculated the seed rate of each entry:
   For calculation of desired seed, an average 1000 grain weight of 38.0g for bread wheat and 40.0 g is taken as standard.
   Based on the seed rate of 100.0kg/ha for timely sown and 125.0kg/ha for late sown trials of wheat, a multiplication factor is calculated as below:

- For NIVT plot of bread wheat timely sown series: 72.0 g seed is required if 1000 grain weight is 38.0g. Thus a multiplication factor of **1.89** is used to multiply with 1000 grains weight to calculate the seed required.

- For NIVT plot of durum wheat timely sown series: 72.0 g seed is required if 1000 grain weight is 40.0g. Thus a multiplication factor of **1.80** is used to multiply with 1000 grains weight to calculate the seed required.

- For NIVT plot of bread wheat late sown series: 81.0 g seed is required if 1000 grain weight is 38.0g. Thus a multiplication factor of **2.13** is used to multiply with 1000 grains weight to calculate the seed required.

- Similarly, the multiplication factor is doubled for the AVTs (as per plot size)

Timely Sown seed rate (100 kg/ha)			
10000 sq. m			100000g
7.2 sq. m			72g
Multiplication factor based on 1000 grains weight			
38 g for aestivum			72 g
for 'X' g			multiply by 1.89
40 g for durum			72 g
for 'X' g			multiply by 1.81
Late Sown seed rate (125 kg/ha)			
10000 sq. m			125000g
6.48 sq. m			81g
Multiplication factor based on 1000 grains weight			
38 g for aestivum			81 g
for 'X' g			multiply by 2.13

13) Once the seed crate per plot is derived, the seed of each entry is distributed in to the seed packets for each location.
14) The NIVTs are conducted in Lattice Design with two replications, whereas the AVTs replicated four times in RBD design.
15) The seed packets are prepared in such a way, that the same entry is not repeated at same plot for any two locations *i.e.,* the genotypes/entries are randomized.
16) Hence a master layout is prepared wherein the entries are given a specific key number and the key numbers are randomized across locations. Below is given an example of master layout and centre wise Key numbers:

SPL-HPTY-NWPZ (2018-19)

Key No.	Plot No.			
	R I	R II	RIII	RIV
1	07	18	35	53
2	14	16	34	52
3	08	15	38	55
4	13	27	36	43
5	04	20	41	47
6	02	22	40	56
7	09	26	42	54
8	12	17	30	44
9	06	24	37	51
10	11	21	33	45
11	10	28	31	46
12	05	19	29	50
13	03	23	32	48
14	01	25	39	49

Centre wise Key numbers

Entry	Ludhiana	Gurdaspur	Ladowal	Hisar	Karnal	Pantnagar	Delhi
SPL-HYPT-1	7	13	3	4	5	9	7
SPL-HYPT-2	5	9	2	13	6	4	2
SPL-HYPT-3	6	12	1	10	3	11	11
SPL-HYPT-4	10	11	11	12	4	3	1
SPL-HYPT-5	13	7	9	11	13	8	10
SPL-HYPT-6	12	1	10	14	10	1	6
SPL-HYPT-7	3	2	14	3	9	12	9
SPL-HYPT-8	8	6	8	2	12	7	5
SPL-HYPT-9	2	10	12	9	1	5	12
SPL-HYPT-10	9	4	13	7	11	13	8
SPL-HYPT-11	11	5	5	5	14	10	14
SPL-HYPT-12	14	3	4	6	2	2	3
SPL-HYPT-13	1	8	6	8	7	14	13
SPL-HYPT-14	4	14	7	1	8	6	4

17) Each seed envelope is provided with following information:
> *Year*
> *Zone name*
> *Trial Name*
> *Plot Number*
> *Key Number (optional)*

18) Before distribution of seed, the envelopes are arranged Key Number (entry) wise as per the mater layout. The seed envelopes, which are generally water-proof are again covered with protective materials so that these are not damaged in transport.

19) Once the seed for all entries is dispensed in to seed envelopes, these are ranged, centre wise and placed in the boxes to be dispatched to each centre.

20) Before the boxes are sealed, the seed envelopes are ranged plot wise to check for any error. The Layout for each centre and data recording instructions are kept in each box and these are sealed within cloth bags and are further addressed to each cooperating centre.

Chapter - 4
Zonal monitoring of AICRP Wheat and Barley yield trials
Karnam Venkatesh

The All India Coordinated Research Projects in India have been the most successful and the largest and longest running research projects mandated to deliver disease resistant, high quality and high yielding crop varieties to farmers since 1950s. AICRPs through National Agricultural Research System (NARS) comprising ICAR institutes and SAUs has prioritized research programmes to develop improved varieties and matching production technologies suiting to diverse agro-ecological zones of India.

The tremendous success of AICRPs in the last decades has been attributed to one of the several inbuilt mechanisms such as monitoring of disease, yield and agronomic trials at trial conducting centres by a team of multi-disciplinary scientists every year. The team comprising of breeders, pathologists and resource management scientists is constituted every year by the Director ICAR-Indian Institute of Wheat and Barley Research, who is also the project director of AICRP on Wheat and Barley. Monitoring of trials at cooperating centres becomes necessary to maintain the high level of quality standards set to itself as benchmark by the previous years success of AICRP.

All the trials at all the locations shall be monitored by a team of scientists to be deputed by the Project Director. The monitoring team shall have the following minimum composition:

1. Director ICAR-IIWBR/PI/Zonal Coordinator as team leader
2. One or two breeders as members
3. Agronomist as member
4. Pathologist /Entomologist as member
5. Scientist of any other specified discipline as member

The monitoring committees are zone specific and visit the trial conducting centres to evaluate the crop at an appropriate stage of crop like flowering or post flowering stage. The team submits the report to the Director ICAR-IIWBR, Karnal. This report also forms the basis for accepting or rejecting the data from various trials or in dropping a entry from further testing due to presence of abnormalities such as genetic segregation, admixture etc.

The following points are evaluated by the monitoring team

1. The team shall record observations on the quality of trial conduction as per specified norms and comment on reliability of the data likely to be generated.
2. The monitoring team shall record observations on uniformity within the test plots, crop stand, disease and insect-pest incidence, bird damage etc. and any other feature having a bearing on quality of data generated and attributable to the crop management aspects.
3. The monitoring team shall also indicate an estimate of yield of the trial on the basis of their observations.

The pro-forma of monitoring report is shown below

Proforma for Zonal Monitoring Report -template

Zone: XXX

Team-I		
Period	**Team**	**Centers visited**

Breeding trials allocated & monitored:

Centre	Trial	Remark

Trials not conducted/rejected by monitoring team:

Centre	Trial	Remark

Entries recommended for purification

Trial	Entry	Remarks

Entries recommended to be dropped from further testing:

Trial	Entry	Remarks

Report on Agronomical Trials:

Trial	Centre	Remark

Report on Pathological Nurseries:

Centre	Nursery	Remark

Report on Physiology Trials MLHT-1 & 2:

Centre	Remark

Special comments, if any

Signature of the monitoring team

XXX   XXX   XXX   XXX   XXX

Chapter – 5
Recording of data in Breeding, Pathology and Quality trials
Vikas Gupta

Breeding trials under AICRP on wheat and Barley

The NIVTs and AVTs constituted by ICAR-IIWBR and Zonal Coordinators were dispatched to different centres for trial conduction. After trial planting different traits needs to be recorded like percent germination, days to heading, days to maturity, plant height, lodging and grain yield. After harvesting the post-harvest traits like grain colour, grain texture and 1000 grains weight. The instructions for trait recording are presented in table below.

1. **Days to heading**: It is calculated as days taken from sowing to emergence of 75% of ears (spikes) in a plot. Observation on off-type plant(s) should not be considered.
2. **Days to maturity**: Total days taken from sowing to maturity when all the plants in the plot show natural senescence and the grains become hard and fit for harvesting.
3. **Plant height**: Measured at the time of maturity in centimeters from the ground level upto the terminal spikelet, excluding the awns. Care should be taken to record the measurement from the most commonly representative plants in the plot.
4. **Lodging**: It is visually determined in plots per replication and recorded in percentage when plants are bent at more than 30° angle.
5. **Threshability**: It is recorded either Easy (Ey), Medium (M) or Hard (H). In easy threshability grains are easily separated when earheads are crushed between the palms. Medium-hard threshability is, similar to well-known variety Sonalika. Hard threshability is commonly observed in synthetic wheats and some dicoccum varieties.
6. **Grain colour**: This trait is recorded in three categories i.e., Amber (A), White (W) or Red (R). Most of the test entries bear amber coloured grains, few might be white (associated with soft grain texture) and rarely red (except in case of Dicoccum and Triticale).
7. **Grain texture**: Grain texture is recorded in three categories i.e., Hard (H), Semi-hard (SH) or Soft (So). Hard grains make a typical sound when crushed between the teeth. A hard grain is vitreous and shining, while a soft grain has dull appearance. Semi-hard category is in-between hard and soft grains. Maximum varieties or test entries usually belong to semi-hard class.
8. **1000-grains weight**: Bulk harvest of grains from a test entry should be utilized to draw sample(s) for counting grains (250, 500 or 1000 in number) and their weight is recorded in grams using electronic balance. Grain counter may be used, wherever available, for increasing efficiency and precision.
9. **Grain yield per plot**: Two border rows (one row from each side) of the gross plot should be removed to record the grain yield from the remaining rows which comprise the net plot (4 rows in case of NIVT/IVT and 10 rows in case of AVT). The net plot grain yield should be recorded in grams using electronic balance.

Disease scoring in wheat: Wheat production is constrained by various wheat diseases caused by fungal, bacterial, and viral pathogens. Of these, diseases caused by the rust fungi have since long been a major concern and problem for breeders and farmers. Rust diseases of wheat are among the oldest known diseases and are important worldwide (Singh et al., 2005). Globally,

yellow rust (*Puccinia striiformis* f. sp. *tritici*), stem rust (*Puccinia graminis* f. sp. *tritici*), and leaf rust (*Puccinia triticina*) are the most damaging diseases of wheat and other small grain cereals. The diseases have been contained so far by the use of host resistance as well as fungicides.

1. Rusts:

a. Seedling resistance test: The resistance genes are postulated based on seedling resistance test. The seedling resistance genes can be detected and are effective at the seedling stages, and they are characterized by the gene-for-gene interaction model. Genotypes of the Advanced breeding trials, and other wheat and barley lines from Indian Breeders/Geneticists, are
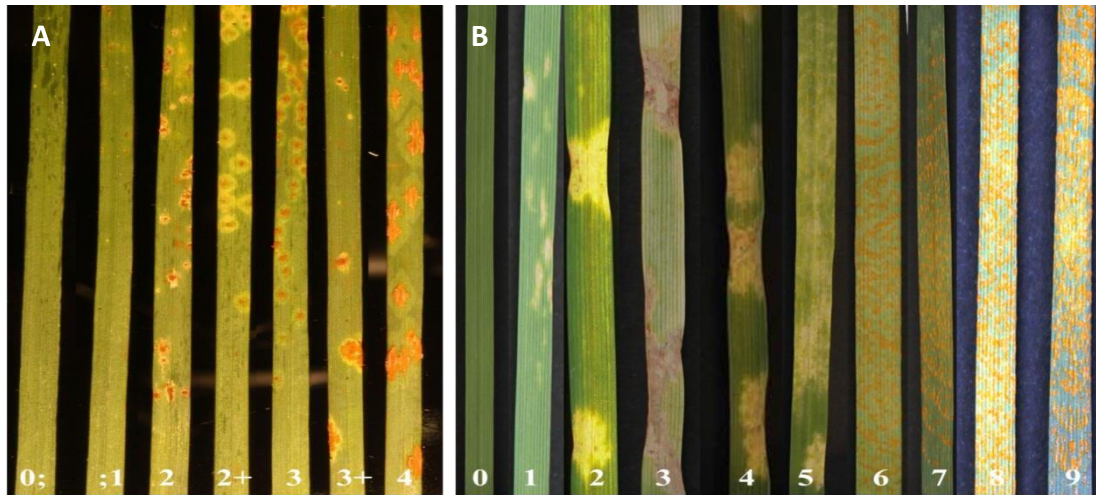
evaluated for SRT at seedling stage using an array of pathotypes of black (*P. graminis* f.sp. tritici), brown (P. triticina) and yellow rust (P. striiformis) having

different avirulence/virulence structures at ICAR-IIWBR RS, Flowerdale Shimla. To identify rust resistant lines of wheat & barley and characterize rust resistance genes in wheat lines using gene matching technique, one week old seedlings were inoculated and incubated in saturated humidity chambers for 48 hours. Subsequently these plants were transferred on to the greenhouse benches where sufficient day light (more than 10,000 Lux) and temperature of 16±20C (for yellow rust), 22±20C (for brown rust) 24±20C (for black rust) and relative humidity of 80-100% were maintained. The disease scoring is presented in Table as per the symptoms.

Table. Disease scoring for different types of rusts in seedling resistance test.

Infection type		Host response	Symptoms
McNeal et al. (1971)	McIntosh et al., (1995)		
0	0	Immune	No visible uredia
1	;	Very resistant	Necrotic flecks
2	;N	Resistant	Necrotic areas without sporulation
3-4	1	Resistant	Necrotic and chlorotic areas with restricted sporulation

5-6	2	Moderately resistant	Moderate sporulation with necrosis and chlorosis
7-8	3	Moderately susceptible	Sporulation with chlorosis
9	4	Susceptible	Abundant sporulation without chlorosis

b. Adult Plant resistance evaluation:

Wheat breeders and pathologists have always been concentrating on APR genes in order to identify and improve the level of resistances. The detection of APR is usually conducted at the post-seedling stage, and is often referred as field resistance. APR genes are effective only in APR stages, but have been shown to be an important part of durable rusts resistance. To identify rust resistance that is functional at adult plant stage (APR) in AVT entries of wheat against Pst, and Pt pathotypes, experiments are conducted under controlled polyhouse conditions. The most virulent pathotypes of yellow rust, brown and black rusts are used in these studies. Optimum conditions for infection of rust and growth of wheat material were provided. The APR disease responses and severities based on the modified Cobb scale (Peterson et al. 1948), and the reaction types by Roelfs et al., (1992) are presented in Table.

Table: Adult plant resistance response and severity for rust

Disease response	Disease severity %	Host Response	Symptoms
R	0-5	Resistant	Resistant, no visible infection or some chlorosis or necrosis and no uredia
R-MR	10-20	Resistant to moderately resistant	Moderately resistant, small uredia present and surrounded by either chlorotic or necrotic areas
MR	20-30	Moderately resistant	
MR-MS	30-40	Moderately resistant to moderately susceptible	
MS	40-50	Moderately susceptible	Moderately susceptible, medium-sized uredia present and possibly surrounded by chlorotic areas
MS-S	50-70	Moderately susceptible to susceptible	
S	70-100	Susceptible	Susceptible, large uredia present, generally with little or no chlorosis and no necrosis

Average coefficient of Infection (ACI): After recording of disease data in the trials for individual locations the ACI is calculated. For ACI to be calculated at least three location disease data is required otherwise highest score is to be recorded in the ancillary characteristics table. The ACI is calculated by multiplying the disease score with the factor given in the table below for each location and then calculate the average.

ACI Factors

Rust score	Factor	Rust score	Factor
R	0.2	T	1
MR	0.4	Ts	1
MS	0.8	tMR	0.4
S	1.0	tMS	0.8
X	0.6	tr	0.2

2. Spot blotch

For identification of spot blotch resistance, sowing was done at Wadura and Coochbehar locations where spot blotch appear under natural conditions. Sowing was done slightly late (third week of December) so as to synchronize post-anthesis stage with warm temperature and high humidity. Border rows of each block (20 genotypes) were planted with blend of susceptible genotypes (infector) to provide equal chance of infection for each test entry. For recording data on stem rust disease, three recordings following double digit (DD) score method as proposed by Singh and Kumar (2005) were made based on per cent leaf area covered due to stem rust on the flag leaf (digit D1) and the penultimate leaf (digit D2) on the basis of infection. response of the per cent of spot blotch area. The disease severity (DS) was calculated as given below:

Disease Severity% = (D1/9) x (D2/9) x100

Where, D_1= First digit (height of infection) and D_2= Second digit (severity of infection)

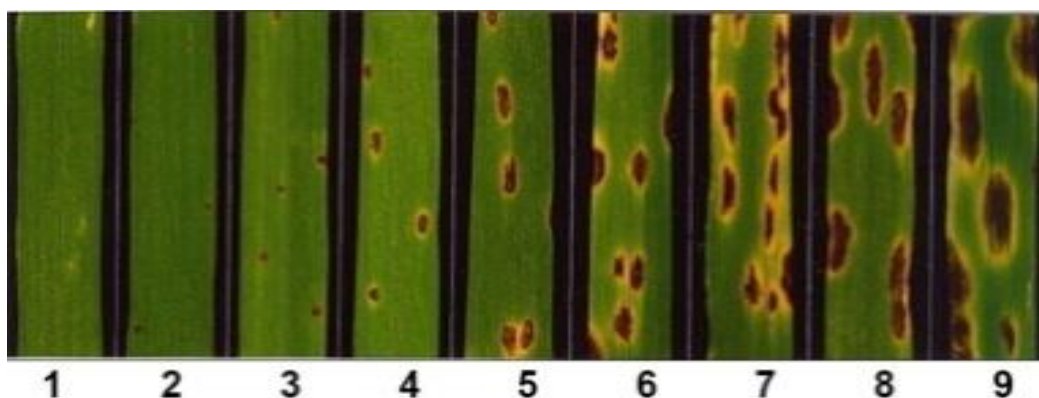Fig: double digit scoring

Where,

1=10% coverage	2=20% coverage
3=30% coverage	4=40% coverage
5=50% coverage	6=60% coverage
7=70% coverage	8=80% coverage
9=90% coverage	

Estimation of area under disease progress curve

The area under disease progress curve (AUDPC) was calculated by summarizing the progress of disease severity. The pattern of epidemic in terms of number of lesions, amount of diseased tissue, or number of diseased plants is given by a curve, called the disease progress curve, that shows the epidemic over time, and the area covered by this curve is known as AUDPC. The area under disease progress curve (AUDPC) was calculated from the multiple disease evaluations, using the following formula:

$$\text{AUDPC} = \sum_{i=1}^{n}[\{(Y_i + Y_{(i+1)}) / 2\} \times (t_{(i+1)} - t_i)]$$

Where,

Yi= disease scored on ith first date

Ti= date on which the disease was scored

n = Number of dates on which disease was scored.

3. Karnal Bunt:

Evaluation for Karnal bunt resistance is done by artificially inoculating the plants using boot leaf inoculation technique developed by Aujla et al. (1982). The inoculum was prepared by mixing 10,000 sporidia/ ml water. Appropriate relative humidity (60–100%) was maintained in the field with the use of water sprayers and frequent irrigations during the inoculation period. At maturity the inoculated heads were threshed manually. The total and infected grains from each plant in every line were counted and per cent infection was calculated. Disease scoring was based on the percentage of infected grains (Fuentes-Davila and Rajaram 1994). Accessions were considered resistant when grain infection percentage was below 5% in 10 inoculated spikes.

4. Powdery Mildew:

Evaluation of powdery mildew resistant accessions was done under natural infection conditions. For spread of inoculum susceptible varieties are also grown along with the test lines. Data was recorded when the infection on susceptible check was at its maximum following the scale 0–9 given by Leath and Heun (1990). The scale is based on infection types where 0 = immune (no visible sign of infection); 1–3 = resistant (1 = flecks with no necrosis, 2 = necrosis and 3 = chlorosis, while amount of mycelium went from none to detectable amount); 4–6 = moderately susceptible (chlorotic area decreasing in amount but mycelium an d conidia production increases); 7–9 = Highly susceptible (increasing amount, size and density of mycelium and conidia to a compatible reaction).

5. *Fusarium* head blight (FHB):

The experiment for identification of FHB resistance are conducted under controlled polyhouse conditions. Mass culture of Fusarium spp./isolates was raised on potato dextrose Agar (PDA) media at 25 ± 2°C for two weeks. The inoculum was prepared by flooding the petriplates with sterile distilled water containing Tween 20 (polyoxyethylene sorbitan monolaurate), scraped mycelial mat with spores and straining the resulting suspension through double layer sterile

cheese cloth and adjusted to a concentration of 1 x 10^4 spore/ml using sterilized distilled water. Two spikes at anthesis of all the 247 accessions were inoculated with Fusarium isolates by Cotton wool ball technique described by Singh et al. (1995). Each spike was covered with a plastic bag to prevent cross contamination and proper humidity was maintained (RH>90%) for 72 h. Mist was created to maintain the desired humidity. Disease data were recorded visually by counting healthy and infected spikes as well as infected spikelets per spike in each plant at 7 days after inoculation. Per cent infected spikelets (% disease severity) were calculated as: (No. of infected spikelets/Total spikelets per spike)*100. The percent disease score was converted to a scale of 0–5 as:

0- Free/Immune reaction; 1- FHB infection up to 10%; 2- FHB infection of more than 10% and up to 25%; 3- FHB infection of more than 25% and up to 50%; 4-FHB infection of more than 50% and up to 75%; 5-FHB infection of more than 75%.

6. Loose smut

Artificial inoculations were done using smutted heads from the susceptible genotype (PBW 343) inoculated in the previous year with race *T11* of loose smut. The florets of the ear to be inoculated were clipped open with scissors at the early anthesis stage. The ear was then covered with a parchment paper bag. Inoculations were performed by cutting open the bag from top and dusting spores from smutted earheads from the infected genotype. After inoculation the cut end of the bag was stapled. Infection levels were scored as percent plant infection; any plant with one or more smutted ears (completely or partially smutted) was recorded as infected.

Evaluation for quality traits:

The NIVT and AVT entries are also tested for various quality parameters besides evaluation in agronomy, pathology and breeding. The AVT and NIVT entries are evaluated for grain Appearance, Hectolitre Weight, Protein Content, Sedimentation Value, Grain Hardness Index, Phenol Test, Yellow Pigment Content, Fe and Zn content and High Molecular Weight Glutenin Subunits. The AVT entries are also tested for Chapati, Bread, Biscuit, Pasta and Gluten parameters. The quantity of seed required for NIVTs and AVTs is 100 and 250 gm respectively. The quality parameters for different products are presented in Table.

Product	Grain Texture	Protein (%)	Gluten strength
Chapati	Hard	Medium to high (10-13)	Medium and extensible
Bread	Hard	High (>13)	Strong and extensible
Biscuit/ cake	Soft	Low (8-10)	Weak and extensible
Pasta	Very Hard (Durum wheat)	High (>13)	Strong

Physico-Chemical Characters

The grain samples were evaluated for the following physico-chemical characteristics using standard methods:

i). **Grain appearance score**: It was evaluated subjectively out of a maximum score of ten giving due weightage to the grain size, shape, colour and lustre.

ii) **Grain hardness**: The grain hardness was measured by using the grain hardness tester (supplied by M/S Ogawa Seiki Co. Ltd., Japan) by crushing ten grains one by one taken randomly from the lot. The mean force (kg) required to crush the grain was recorded.

iii) **Test weight:** This was determined using the apparatus developed by the ICAR-IIWBR, Karnal, which employs a standard container of 100 ml capacity (Mishra *et al* 1998). The grains were weighed and the test weight expressed in kg/hl.

iv) **1000-grain weight:** 250 kernels were counted in duplicate from a random seed lot of each plot and weighed. The average weight obtained was multiplied by four and expressed in grams.

v) **Moisture content:** The moisture content was estimated using the whole grain analyzer Infratec 1241 supplied by M/S Foss Analytical AB, Sweden. The instrument uses the near infrared light transmitted through the grains. The grain samples were scanned in the range of 850 to 1050 nm with a bandwidth of 7 nm and there were 100 data points per scan. The results were displayed as percent moisture content.

vi) **Protein content:** The grain protein content was estimated using the whole grain analyzer Infratec 1241 supplied by M/S Foss Analytical AB, Sweden. equipment was calibrated using grain sample of known protein content estimated using the Kjeldahl method. The instrument uses the near infrared light transmitted through the grains. The grain samples were scanned in the range of 850 to 1050 nm with a bandwidth of 7 nm and there were 100 data points per scan. The results were displayed as percent protein content.

vii) **Gluten content and Gluten index:** The gluten content and index values were evaluated using Glutomatic 2100 system supplied by M/S Perten, Germany. The instrument employs a 10g sample of whole meal using the AACC method. The wet gluten content was calculated from the weight of the two fractions obtained after centrifuging for gluten index determination. The wet gluten was then dried in the Glutork gluten drier and the weight expressed as percent. The gluten index is expressed as the percent wet gluten retained inside the centrifuge cassette.

viii) **Sedimentation value:** The SDS sedimentation values of samples were determined by employing the method given by Axford *et al* (1979). A sample weight of 6g and a rest period of 20 min were employed. On the basis of SDS sedimentation values, the wheat lines may be classified as follows:

Sedimentation Value (cc)	Wheat Class
Below 48	Weak
48-68	Medium Strong
Above 68	Strong

ix). **Phenol test**:

The phenol reaction of the wheat genotypes was determined by soaking 15-20 grains of each sample in distilled water for 15-16 hours in Petri plates. After that the water was drained off and 1 per cent solution of phenol was added to the grains so that only three fourth of the grain is covered by the solution. The Petri plates were covered and kept for 4 hour. After 4 hours the phenol solution was also drained off and the grains were dried of filter paper for 30 minutes. A subjective score (out of 10) was given to each genotype

based on the colour after drying. Higher score was given to the grains with darker intensity of the colour.

x). **Carotenoids**: Standard AACC calorimetric method was used to determine the amount of carotenoids in the wheat wholemeal for all the genotypes. 4 g wholemeal was taken in a 125 ml reagent bottle and 20 ml of water saturated n-butanol was added to it. The contents were mixed properly and kept in dark for 16 hours. The contents were then filtered and the extract transferred to standard test tubes. Light transmission of the extract was measured at 440 nm using spectrophotometer and recorded as optical density (O.D.). The amount of carotenoids was calculated using the following formula:

Carotenoids (ppm) = [(O.D. X 23.5366) + 0.0105]

xi). **Sugar content**:

AACC (1990) approved method was followed to determine the reducing and nonreducing sugar contents. The sugars were extracted from 5.7g of flour in sodium acetate buffer. The proteinacious material was precipitated by the addition of sodium tungstate (12.0%). The contents were mixed and filtered. From the filtrate, 5 ml ali quot was taken and the reducing sugars were determined by potassium ferricyanide method. The total sugars were also estimated by potassium ferricyanide method but the 5 ml aliquot was first hydrolyzed by immersing in boiling water bath for 15 min. The difference between the total and reducing sugars gave the content of non-reducing sugars. Reducing sugars were expressed as per cent maltose whereas non-reducing as per cent sucrose.

xii). **Diastatic activity:** It was determined using AACC (1990) approved method employing 5 g of flour sample. The sample was incubated with 46ml of acetic acid sodium acetate buffer (pH 4.6-4.8) for 1 hr at 30°C. The enzyme action was terminated by adding 2 ml of sulphuric acid (10%) followed by the addition of 2 ml of 12% sodium tungstate solution. The contents were filtered through Whatman No.4 filter paper and a 5 ml aliquot was taken for maltose determination by the potassium ferricyanide method. The results were expressed as percent maltose produced.

xiii). **Falling Number Value (sec)**: The Falling number values were estimated using the Starch Master supplied by New Port Scientific, Australia using the following procedure: Switch on the instrument and allow it to warm up for 30 min, weight 4.0 g (14% moisture basis) of whole meal in a consister and add 25.0 ml of distilled water into the consister. Place the paddle into the consister and vigorously jog the blade through the sample up and down 10 times or until it mixes uniformly. Insert the consister into the pre-adjusted instrument using the standard profile given below:

Time	Type	Value
00:00:00	Temp	95°C
00:00:00	Speed	960 rpm
00:00:00	Speed	160 rpm

Idle Temperature	: 95 ± 1°C
End of Test	: 3 min
Time between readings	: 1 sec

Measurement cycle was initiated by depressing the motor tower of the instrument. The consister was removed on completion of test and discard. The falling number values displayed at the end of the test were recorded.

xiv). **Chapati-making characteristics**: The whole meal was produced by grinding the grains in a laboratory stone grinder (Chakki). The gap between the two stone discs was adjusted so as to pass the meal through 40 micron mesh sieve. The 50 g whole meal (atta) and optimum quantity of water were mixed mechanically for 2 min using Swanson mixer. The dough was evaluated for stickiness while rounding it up manually and kept in the humidity cabinet maintained at 30°C and 80% R.H for 30 min. The dough was sheeted to 2mm thickness with the rolling pin and chapaties of 15.0 cm diameter were cut using appropriate die. Chapaties were baked on an automatic roti-maker having thermostatically controlled constant temperature for 20 sec on one side and for 40 sec on other. Finally it was puffed for 10 sec by turning the chapati and bringing the upper plate of the roti-maker in contact with the chapaties. Chapaties were cooled to room temperature in the humidity cabinet and evaluated by a panel of trained judges using the evaluation performa based on dough stickiness (5), puffing of chapati (5), color of chapati (5), texture of chapati (5), taste of chapati (5), flavor of chapati (5) and texture of chapati after 2 hrs (5). The total score was finally calculated out of a maximum of 10.

Bread making characteristics

Bread Baking: Straight dough method with remixing (Irvine and McMillan, 1960) was followed by using optimum quantity of water. The baking formula consisted of the following:

Ingredients	Quantity
Flour	100 g
Compressed baker's yeast	2.5 g
Sugar	2.5 g
Shortening	1 g
Water	Optimum

The contents were optimally mixed in the Swanson mixer (National Mfg. Co. U.S.A) and the following baking schedule was used.

Operation	Time
Mixing	Optimum
Fermentation	1 hr, 30 min
Remixing	15 sec
Recovery	25 min
Proofing	55 min
Baking	20 min at 410 F

After mixing, the dough was evaluated subjectively for its stickiness and fermented in the fermentation cabinet at 86°F and 80% R.H. The dough was then remixed for 15 sec in the mixer. The dough was allowed to recover for 25 min before sheeting and moulding. The moulded dough was proofed for 55 min in the fermentation cabinet and baked in a revolving reel baking oven at 410°F.

The loaves were cooled to room temperature and weighed. Volume was measured using rapeseed displacement method of Bennington and Geddis (1938). The loaves were evaluated for crust and crumb characteristics the next day using the following evaluation Performa:

	Characteristic	Max. Score
Dough	Stickiness	5
Crust	Color	5
	Appearance	5
Crumb	Color	10
	Texture	15
	Grain	15
Loaf	Taste & Flavor	15
	Volume	30
Total		100

The loaf volume score (LVS) was calculated using the following expression:

$$LVS = \frac{\text{Loaf Vol} - 300}{20}$$

Chapter - 6
Physiological traits for phenotyping under field conditions
Mamrutha HM and Sindhu Sareen

The collection of phenotypic data for different traits of individual plant genotypes is a prerequisite for any crop improvement research. Phenotyping is required not only for making decisions about how to breed better crops for the future, but also for the identification of the genomic regions that confer improved traits in the crop plants. Phenotype may be due to single gene, or due to multiple genes which can generate different phenotypic outcomes based on how they interact with each other and with the environment. Some of the common and simple field phenotyping traits and the instruments used are discussed below.

Canopy temperature: It has been extensively used in wheat breeding programmes for selecting high yielding genotypes. Plant canopy emits long wave infrared radiation as a function of its temperature. This property of plant canopy is used as selection criteria with a fact that the genotypes with low canopy temperature are able to extract moisture from deeper layer of soil or by minimising the stomatal water loss and will have higher yield. There are several studies indicating this as promising trait for screening large number of genotypes under drought (Balota et al., 2008). As it is non-destructive, can be measured fast under field condition, covers larger genotypes in field and selection for this trait indirectly allows for the selection of genotypes with better water use, deep root and stomatal conductance under abiotic stress. Preferred time for observation is at or just after noon.

Leaf chlorophyll content: The chlorophyll pigment absorbs all colors of light and reflects green color. Hence, it is green in color. The canopy greenness is directly related to photosynthetic efficiency of the plants. Measure of leaf chlorophyll content by optical sensing is used as one of the trait for genotypes screening under field conditions. The instrument used is called chlorophyll meter and the measurements taken are chlorophyll content index (CCI). The CCI values vary depending on chlorophyll meters used from different companies. However, the values are used in relative terms and observations can be taken at any time of the day.

Chlorophyll fluorescence (CFL): It is used indirectly for measuring photosynthetic efficiency of the genotypes, mainly interms of Photo system II (PSII) function. CFL measures Fv/Fm ratio i.e. immediately after dark adaptation when leaf is exposed to light. The maximum amount of photons used for photochemistry is estimated as ratio of Fv/Fm where in Fv-Variable fluorescence and Fm-Maximal fluorescence. Under non stress condition with maximum photon utilization for photochemistry the ratio of Fv/Fm obtained is 0.79-0.84. Minimum 15-20 minute of dark adaptaion is required for CFL measurement. The observation timing is between 11AM-2PM and should be recorded on a bright sunny day. Photosynthesis measurement using IRGA under field condition is a laborious process, hence, CFL readings are recorded for faster screening of large wheat genotypes for higher photosynthetic efficiency under field conditions.

Normalized difference vegetation index (NDVI) and digital imaging: The green leaves absorbs light in visible region and emits in the form of long wave radiation at near infrared region(NIR), NDVI basically measures light at NIR region and inturn tells about the canopy coverage. Higher the canopy/vegetation, higher will be the reflectance and NDVI value. This parameter is used in wheat breeding programme to assess the variability in early vigour, ground

cover, biotic/abiotic stress effect, senescence, nutrient use efficiency (nitrogen) etc (Verhulst and Govaerts, 2010a). Other than this, the digital picturing of the canopy can also be done at same height from the ground level and pictures can be analysed with the available softwares (Adobe photoshop CS3 extended or later version) to assess the early ground cover (Mullan and Reynolds, 2010). The green area index (GAI) is other parameters used for assessing green canopy cover in field. The portable NDVI machines are used for recording data. Reading can be taken at any time of the day. NDVI values ranges from 0 to 1. Zero represents no greenness and one represents maximum greenness.

Stomatal Conductance: Stomatal conductance estimates the rate of gas exchange (*i.e.,* carbon dioxide uptake) and transpiration (*i.e.,* water loss) through the leaf stomata as determined by the degree of stomatal aperture. It is a function of the density, size and degree of opening of the stomata. The handheld porometer provides rapid measurement of leaf stomatal conductance. The heritability of stomatal conductance is reasonably high and gives high correlation with yield.

Leaf area Index: Leaf area index measures the functional leaf area over unit land area. It represents leafiness in relation to land area at an instant time. Hand held LAI meter is used for recording leaf area under field conditions. The optimum LAI recorded in crops is between 4-6 under good input conditions.

Fig.1: Different physiological instruments used in field phenotyping (A) Infra red gun (B) Chlorophyll meter (C) Porometer (D) LAI meter (E) CFL meter (F) NDVI

Chapter - 7
Agronomy trials: conduction and data recording
Ramesh Kumar Sharma

Introduction

Wheat is a premier cereal crop and beside staple food for human beings its straw is a good source of cattle feed in our country. In India it is grown on an area of about 30 m. ha and a record production of 102.3 million tonnes at productivity of over 3500 kg/ha was achieved during 2018-19 season. To draw appropriate conclusions, it is very important to plan and conduct the trials meticulous taking care at every stage of experimentation followed by proper data recording with minimum errors.

Climatic requirement

Wheat crop requires cool and moist climate during its early part of growth. A warm temperature at this stage is unfavourable to tillering and also promotes diseases. Too much rain promotes rust incidence in this crop. Hot and dry season at the time of maturity ripen the grain uniformly.

Time and method of sowing

Optimum time of wheat sowing is when the mean daily temperature is around 23 °C as the satisfactory germination could be obtained within a temperature range of 20-25 °C. For good tillering temperature should range from 16-20 °C. This desired level of temperature is found in the first fortnight of November in almost all the wheat growing areas. If sowing is delayed beyond 25th November, yield reduction of 30-40 kg/ha/day may be observed. For proper experimentation, the seeding must be done using precision drill having distributor. In fertiliser trials precision drill having two distributors, one for seed and other for fertiliser, should be used.

Seed rate and spacing

Normally a seed rate of 100 kg/ha is recommended if the 1000 grain weight is 38 g for timely sown conditions. The seed rate should be increased to 125 kg/ha at 1000 grain weight of 38 g for late sown. Therefore, the seed requirement is actually dependent on seed size, germination percentage, time and method of sowing. Seed should be well cleaned to remove shrivelled and small grains including weed seeds. Seeding depth should be around 5 cm with a row spacing of 18-21 cm. For late sown wheat reduce the spacing to 15-18 cm. For seed size the following correction formula should be adopted;

$$\text{Seed rate required for particular variety} = \frac{100}{38} \times 1000 \text{ grain weight}$$

Type of trials

The agronomy trials conducted are of two types *i.e.* Evaluation of final year entries for different growing conditions and updating the zone specific package of practices

1. Evaluation of final year entries
   i. Evaluation of final year entries at different dates of sowing
   ii. Evaluation of final year entries under restricted irrigation
   iii. Evaluation of final year entries under rainfed conditions
2. Updating the zone specific package of practices
   i. Fine tuning the fertiliser requirement for yield maximization under different growing conditions

ii. Fine tuning the irrigation requirement under different growing conditions
iii. Developing weed management strategies for different agro-climatic zones
iv. Diversification/intensification of zone specific cropping systems
v. Reducing the production cost and improving profitability through adoption of resource conservation technologies with special emphasis on tillage.

For uniformity in data recording and reporting following points should be strictly adhered to

1. Sequence of treatments should be strictly as per the technical programme. Columns/Rows for the missing treatment/variety should be kept blank. Data should be submitted as per the stipulated date given above.

2. To record observations on stand count, earhead/m^2 *etc.*, two fixed quadrants may be marked in each plot.

3. For recording observations on weeds, wherever necessary, two fixed quadrants per plot may be marked. The weed data can be recorded as number/m^2 or dry weight as g/m^2

4. Yield, 1000-grain weight and biomass may be reported at 12% moisture. For this purpose, grain and straw samples may be taken for determining moisture content at the time of recording and data corrected to 12% moisture content.

5. Among yield and yield attributes, the maximum errors in data recording are in grains/earhead when we take earheads randomly from each plot and calculate the grains per earhead. Therefore, for calculating grains/earhead following formula may be used;

$$\text{Grains/earhead} = \frac{\text{Yield, q/ha X 10,000}}{\text{Earhead/m}^2 \text{ X 1000 grain weight, g}}$$

6. For calculating lodging score following formula may be used

$$\text{Lodging Score} = \frac{(\text{Lodged area/Net plot area})*100*\text{Angle of lodging}}{90}$$

7. Data should be reported strictly as per the units given at the top of each page/worksheet/character for different parameters.

Chapter - 8

Coordinated Research for Barley Improvement in India

RPS Verma and AS Kharub

Barley Improvement centres and their specific objectives

Centres	State	Research Priorities
Coordinating unit		
ICAR-IIWBR, Karnal	Haryana	Barley improvement for malting, feed and food
Funded Centres		
Bajaura (HPKV, Palampur)	Himachal Pradesh	Hulled/ huskless barley improvement for northern hills with rust resistance
Durgapura (RAU, Bikaner)	Rajasthan	Barley improvement for malting, feed and forage uses with resistance to rusts, Cereal Cyst Nematode (CCN) and salinity
Ludhiana (PAU)	Punjab	Barley improvement for malting, feed and forage
Faizabad (NDUA&T)	Uttar Pradesh	Barley improvement for saline / sodic soils and blight resistance
Hisar (CCSHAU)	Haryana	Barley improvement for malting, resistance to rusts, salinity and brackish water
Kanpur (CSAUA&T)	Uttar Pradesh	Barley improvement for feed, forage, diara lands, rainfed and salt tolerance
Varanasi (BHU)	Uttar Pradesh	Hulled and huskless barley improvement for diara lands and rainfed areas, leaf blights resistance
Voluntary Centres		
Almora (VPKAS)	Uttar Pradesh	Rainfed barley improvement for disease resistance
Pantnagar (GBPUA&T)	Uttarakhand	Barley improvement for northern plains and hills
Shimla (IARI, RS)	Himachal Pradesh	Rainfed barley improvement for disease resistance

Major challenges in barley:
- Development of superior quality malting barley.
- Develop varieties resistance to biotic and abiotic stress, salinity stress, aphid resistance etc.
- Development of high yielding nutritionally rich food barley
- Development of zone wise production and protection technologies.

Barley Coordination Activities

 The main activities of barley coordination include,

Crop Improvement
- Yield Evaluation Trials,
- Access to new variability (International/ National Nurseries/trials),

- Genetic Resources (Evaluation, Rejuvenation & conservation),
- Organization of Breeder Seed Production,

Barley Crop Protection
- Evaluation barley entries for disease resistance:
  - IBDSN, NBDSN, EBDSN
- Seedling Resistant Test (SRT) of NBDSN and EBDSN at Flowerdale Shimla
- Chemical control of barley stripe rust, leaf blight and Foliar Aphids
- Screening of NBDSN against foliar aphids and CCN

Quality Improvemnt
- Malting quality (Timely & Late sown trials)
- Barley quality component nursery (BQCN)
- Quality evaluation of Feed Barley

Barley Resource management
- AVT final entries evaluation trials
- Special trials for updation packge of practices
  - Climate Resilient technologies/ Conservation technologies
  - Nutrient management-Malt, Feed and Hulless
  - Weed management
  - Irrigation Management
  - Yield maximisation

Varietal development & evaluation centres

SN	Center	SN	Center
1.	Bajaura	7.	Varanasi
2.	Durgapura	8.	Pantnagar
3.	Faizabad	9.	Shimla
4.	Hisar	10.	Almora
5	Kanpur	11.	Karnal (Headquarter Coordination)
6.	Ludhiana		

Sowing time of yield trials in different zones

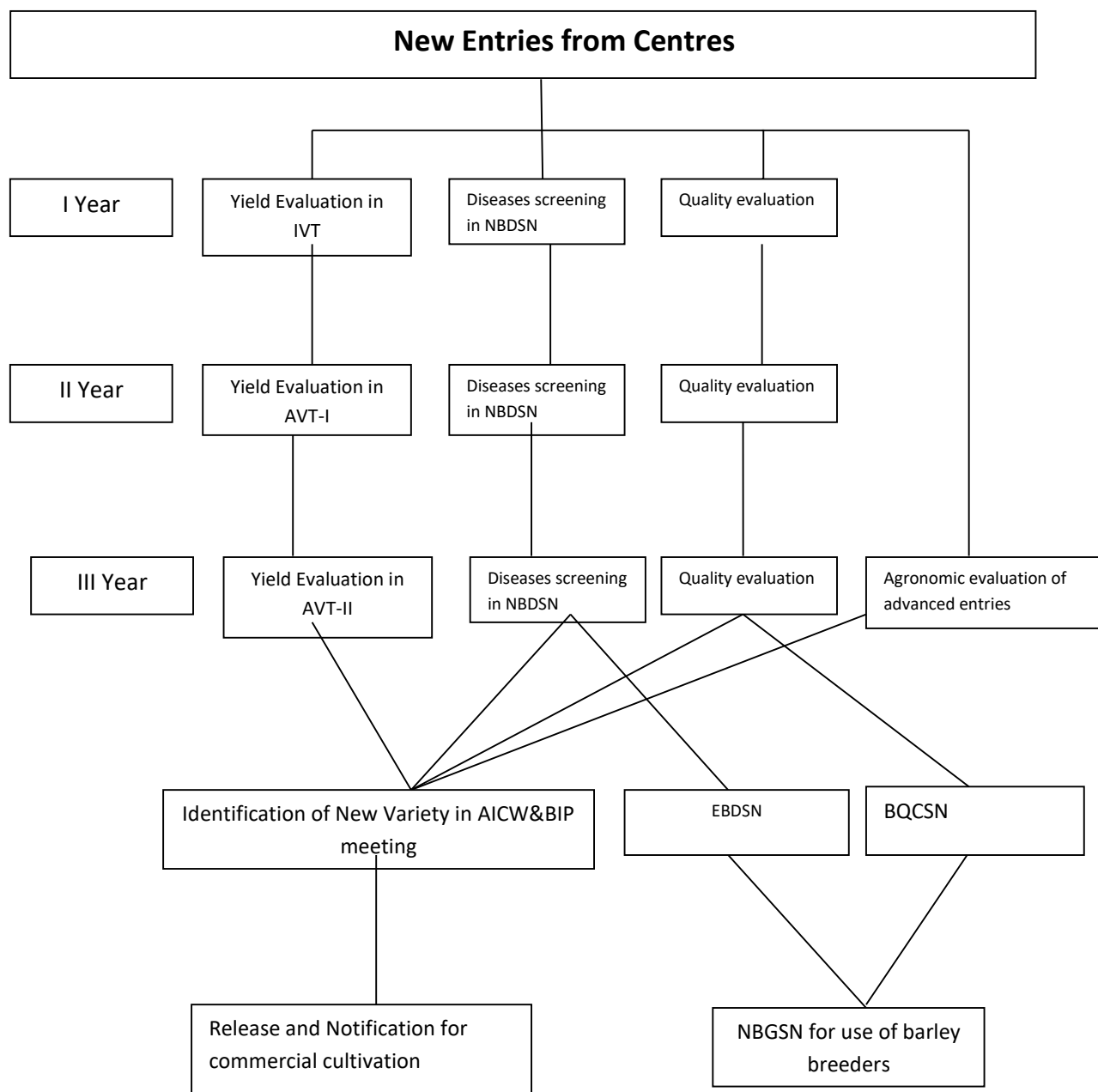| Trial Series	NHZ	NWPZ	NEPZ	CZ
Irrigated trials-TS	-	Nov. 10-25	Nov. 10-25	Nov. 10-25
Rainfed trials	25 Oct-10Nov.	-	Oct. 25-10 Nov	-
Irrigated trails-LS	-	Dec. 10-20	-	-
Irrigated-Dual	-	25 Oct-15 Nov	25 Oct-15 Nov	-

Norms with respect to site mean and coefficient of variation (CV) for acceptance of coordinated yield trials
Limit of site mean (Yield in q/ha)

Zone/Trial	irrigated condition	Rainfed/ salinity condition
NHZ	-	15
NWPZ	30	-
NEPZ	30	15

CZ	30	-
Salinity Alkalinity Trial	12	-
Dual purpose-plains	22 (125 Forage)	12 (20 Forage)
CV	<20%	<25%

Coordinated System of Variety Evaluation and Release in India

New Entries from Centres

| I Year | Yield Evaluation in IVT | Diseases screening in NBDSN | Quality evaluation |

| II Year | Yield Evaluation in AVT-I | Diseases screening in NBDSN | Quality evaluation |

| III Year | Yield Evaluation in AVT-II | Diseases screening in NBDSN | Quality evaluation | Agronomic evaluation of advanced entries |

| Identification of New Variety in AICW&BIP meeting | EBDSN | BQCSN |

| Release and Notification for commercial cultivation | NBGSN for use of barley breeders |

Chapter - 9

Reporting of AICRP Wheat and Barley yield trial data

Karnam Venkatesh

Effective data recording and efficient reporting are the very essential steps necessary for successful achievement of aims of the experiments and it is especially true in AICRP trials where the aim of the trial conduction is to identify improved and widely adopted wheat varieties for commercial cultivation.

Some important tips for effective data reporting are summarized here under

Guidelines for data reporting

The report has to be divided in to three different parts and is as follows. The blank data sheets for all the traits and nurseries coming under AICRP wheat and Barley can be downloaded from www.AICRPwheatandbarley.org website (link).

Item		Details
Weather data of the trial conducting centre		Each trial conducting centre has to necessarily submit the diurnal weather variations in weather parameters such as rainfall (mm), minimum and maximum temperature.
Yield data		Yield data of the trails in grams (four digits) to be reported replication wise NIVTs =2 replications AVTs =4 replications AVT (NHZ trials) = 6 replications
Ancillary data		Ancillary data of the test entries related to phenological, disease reactions and grain characteristics to be reported. All the numerical data are to be reported as average values. All other qualitative data to be reported for single replication

List of Characters for which data should be reported for yield trials

Weather data sheet
1. Weekly min and max temperature (degree C)
2. Weekly rainfall (mm)
3. Number of rainy days in a week starting from sowing in August (Aug 26) till harvesting (Apr 27)
4. Number of sunshine hours in a week starting from sowing in August (Aug 26) till harvesting (Apr 27)
5. Min and max relative humidity in a week

Yield data sheet
1. Grain yield (g/plot)

2. Biological yield or biomass in gram or Kg plot^{-1}

Ancillary data sheet
1. Days to Heading
2. Days to Maturity
3. Height (CM)
4. 1000 Gr. Wt. (gm)
5. Lodging (%)
6. Disease 1 (Yellow rust)
7. Disease 2 (Brown Rust)
8. Disease 3 (Black Rust)
9. Disease 4 (Powdery Mildew)
10. Disease 5 (Leaf Blight)
11. Thresh-ability
12. Color (A=Amber, R=Red, W=White)
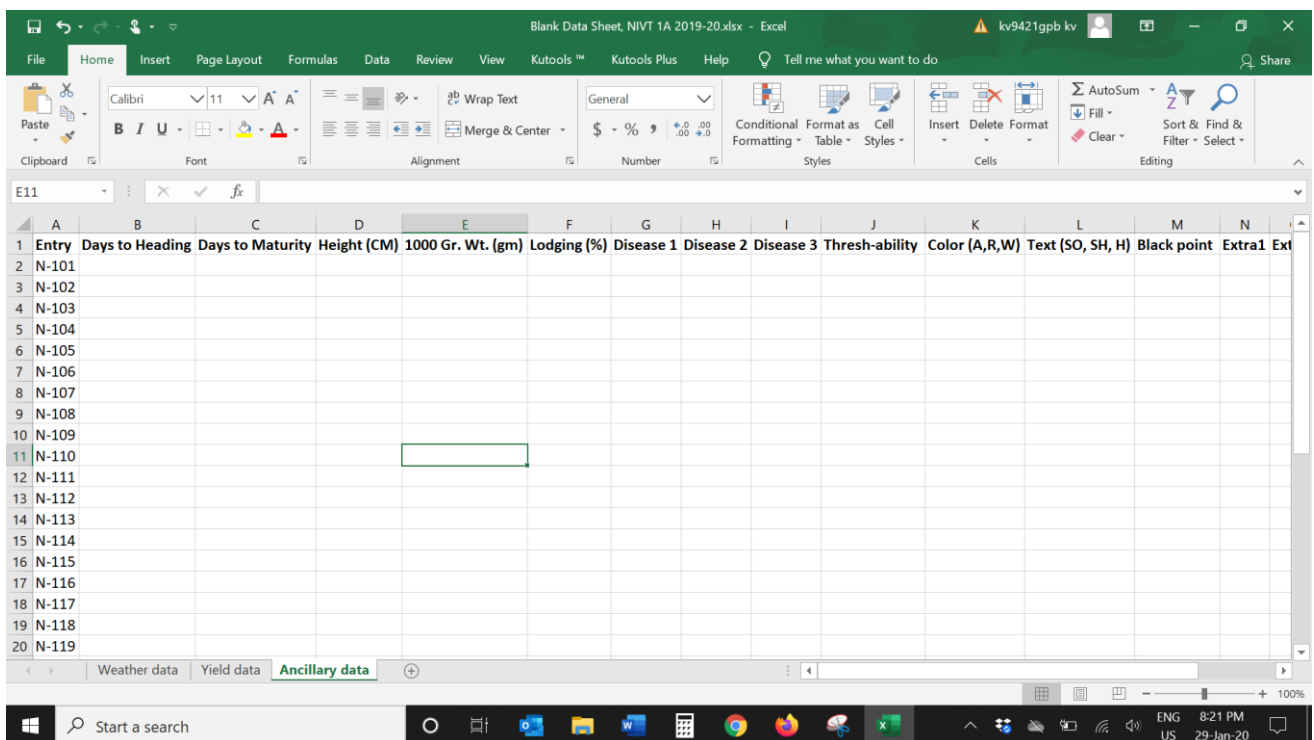13. Text (SO=Soft, SH=Semi Hard, H=Hard)
14. Black point

The screenshot view of a blank data booklet/ excel sheet for reporting weather data is shown as below
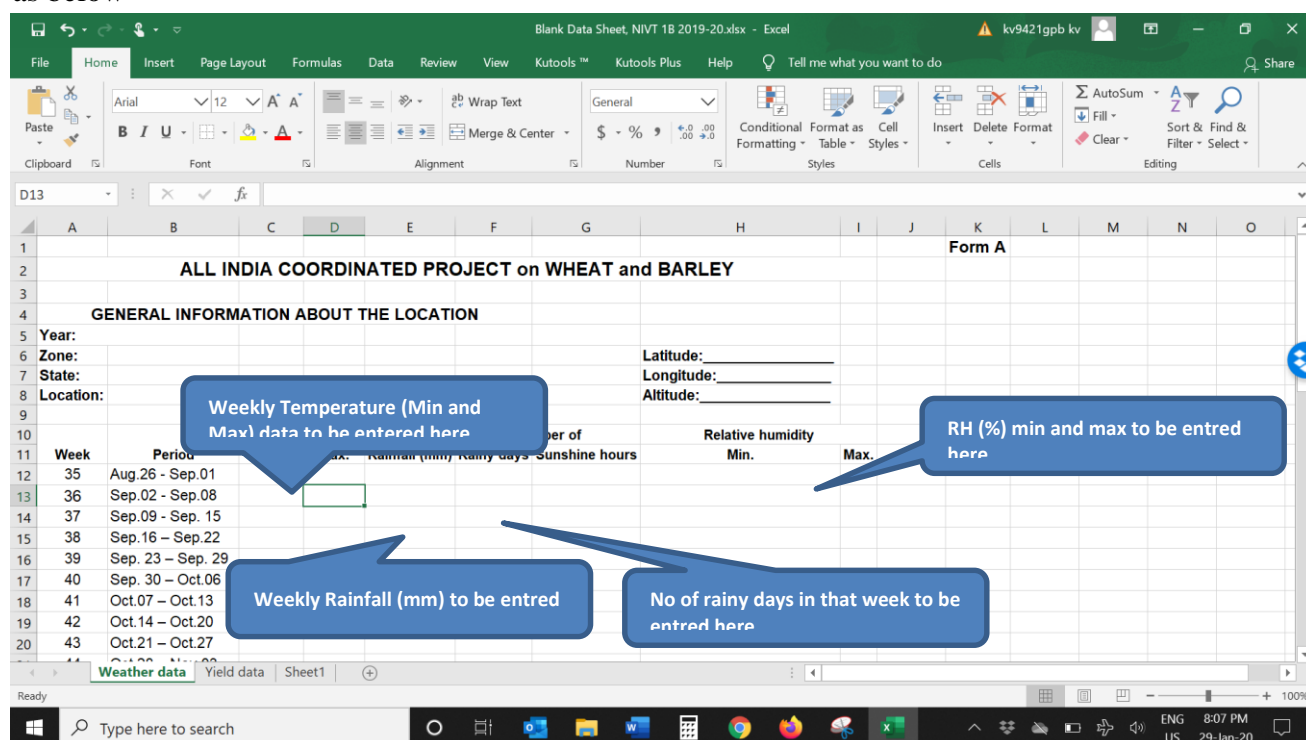
The screenshot view of a blank data booklet/ excel sheet for reporting yield data is shown as below
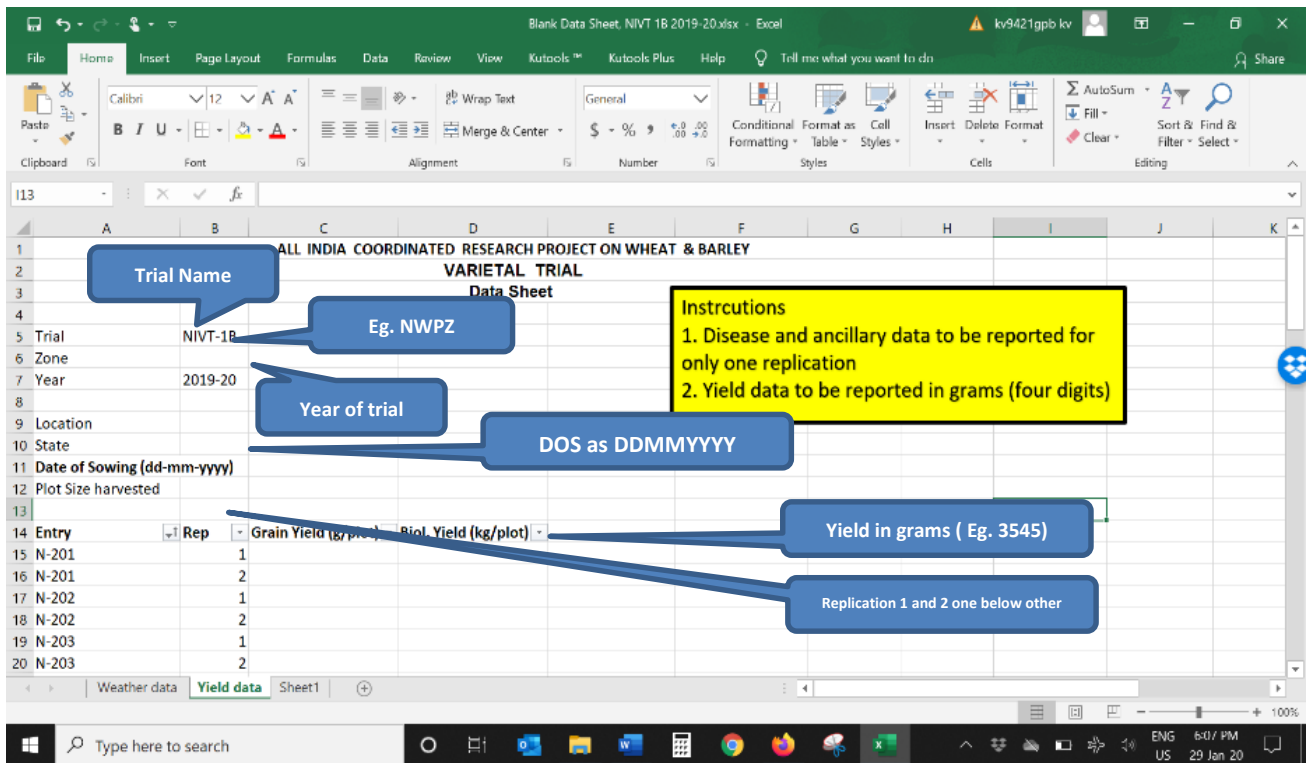
The screenshot view of a blank data booklet/ excel sheet for reporting weather data is shown as below

In ancillary data sheet, additional columns maybe inserted to report data of traits as per requirements of location specific diseases, pests, etc.

Chapter - 10
DUS Testing and Germplasm Management in Wheat
Arun Gupta, Charan Singh and Vineet Kumar

DUS Testing

Most countries give Plant Breeder's Rights to the breeders in order to recoup the investment made in terms of time, money and resources for creating new variety. The Plant Breeders Rights are given on the basis Distinctness, Uniformity and Stability (DUS) testing. During DUS testing, the candidate varieties are to be tested with the existing varieties and morphological characters are examined against the set guideline.

Conditions for Plant variety protection

The breeder's rights shall be granted when the variety is

- **Novel:** If at the time of filing of the application the propagating or harvested material of such variety has not been sold in India, earlier than one year, outside India, in the case of trees or vines earlier than six years, or in any other case, earlier than four years before the date of filing such application.

- **Distinct:** The variety shall be deemed to be distinct if it is clearly distinguishable from any other variety by one or more essential characteristic from any other variety whose existence is a matter of common knowledge at the time of the filing of the application. Common knowledge may be established by reference to various factors such as; cultivation or marketing already in progress, entry in an official register of varieties already made or in the course of being made, inclusion in reference collection, or precise description in publication. Varieties of common Knowledge (VCK) is broad term under PPV&FRA for the purpose of comparing distinctness in any candidate variety/inbred. There is no uniform or widely accepted definition of VCK but VCK can be released varieties, commercial or botanical reference collection, adequate description of variety in any publication, variety under authorised marketing or in circulation or trade or local variety having common knowledge in relevant community.

- **Uniform**: The variety shall be deemed to be uniform if, subject to the variation that may be expected from the particular features of its propagation, it is sufficiently uniform in its relevant characteristics. For vegetative propagated and self-pollinated varieties the basis of assessment is normally the number of off types in the variety, 1 per cent. In particular, for cross-pollinated species the basis of assessment is the variation in comparable variety (relative uniformity).

- **Stable:** The variety is deemed to be stable if its relevant characteristics remain unchanged after repeated propagation or, in case of a particular cycle of propagation. The relevant characteristics are at least those characteristics used for the assessment of distinctness or which are included in the variety description. Generally, when a submitted sample has been shown to be the uniform, the material can also be considered stable. The stability of a hybrid variety should be assessed by examination of the uniformity and stability of its progenitor lines or of the variety itself that the variety is designated by a denomination in accordance with the provision.

Period of Protection: Once the criteria of novelty, distinctiveness, uniformity and stability are established the variety can be registered for 15 years for crop plants and 18 years for trees and vines. The certificate is valid initially for 9 years for trees and 6 years for other crops, which can be reviewed for remaining period.

Seed material required for registration of variety in wheat: 3000g and 100 ear heads are required. The seed should have atleast 95% germination, 98% physical purity and not subjected to any chemical and biophysical treatment. The applicant should also submit the certified data on germination.

Duration of DUS test: Usually the DUS examination requires two independent similar growing seasons, which can be two successive season or two growing cycle in same years.

Design of DUS trial in Wheat: The use of experimental design, lay out of the DUS trail and method of observation and time of observation is explicitly given in DUS testing guideline of specific crop. Design and expected population for recording observation for DUS test in wheat is given below:

- Design: RBD
- No. of rows   6
- Row length   6 m
- Row to row distance   30 cm
- Plant to plant distance   10 cm
- Expected plants/replication   360
- No. of replication   3

Methods and observations: Details of observations to be recorded is given in below

- For the assessment of distinctness and stability observation shall be made on 30 plants or parts of 30 plants, which shall be equally divided among 3 replications (10 plants per replication).
- For the assessment of uniformity of characteristics on the plot as a whole, which shall be done on single visual observation of a group of plants or parts of plant. During such observation the is deemed uniform when the number of aberrant or odd plants or parts of plant shall not be exceeding 2 in 1000.
- For the assessment of uniformity of characteristics on single ear-rows, plants or parts of plant shall be visually observed on all individual ear-rows, plants or parts of plants. An ear-rows having at least one aberrant or odd plant or parts of plant is dealt as an aberrant row. A variety is shall be deemed uniform when the number of such aberrant ear-rows shall not exceed 3 in 100.
- For the assessment of color characteristics, the latest Royal Horticultural Society (RHS) color chart shall be used.

Characteristics for DUS testing in wheat: A total of 38 characters are to be recorded in wheat. These characters are selected from points of view of suitability for description and for DUS testing in wheat not for their commercial value.

Germplasm Evaluation

Germplasm evaluation refers to the agronomic description of the material in a genebank, for traits that are generally important to breeders and researches in crop improvement. For the purpose of utilization, systematic analysis and description of samples is useful both in distinguishing between population, identifying duplicates as well as providing information on the extent of variation with in germplasm collection. The evaluation process in seed crops may involve some of the following steps:

Evaluation

Seed multiplication and preliminary evaluation: During the initial cycle of seed multiplication the evaluator or germplasm curator should note some of the morphological features and other observations of interest.

Systematic characterization: In the systematic evaluation a profile is developed for each accession based certain guideline. In wheat and barley DUS testing guideline is followed for the development of profile.

Trait specific evaluation: Germplasm is tested for particular trait for the identification of suitable donor for utilization in breeding programme.

Design used for Evaluation of Germplasm

Augmented Blocks Design: Have both replicated and unreplicated treatments. Replicated treatments are tested in each block as in a RCBD. Unreplicated treatments occur in only one block - so each block has a different set of unreplicated treatments

Advantages: 1. Save time and money with smaller blocks

2. Still have critical comparisons

3. Flexible with large numbers of treatments

Disadvantages 1. Less precision for comparing unreplicated treatments

2. Missing data for unreplicated treatment means loss of all information on that treatment

Uses:1. Preliminary screening and selection of treatments for future experiments - variety trials and demonstrations

Types of characters and measurement data

The characters of concern to plant breeders can be broadly divided into two groups which are functionally and, to a large degree, genetically distinct. These are grouped into qualitative or observable and quantitative or non-observable characters.

MG : Measurement by a single observation of a group of plants or parts of plants

MS : Measurement of a number of individual plants or part of plants

VG : Visual assessment by single observation of a group of plants or part of plants.

VS : Visual assessment of a number of individual plants or part of plants

Suggested reading

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Singh, A.P., Padmavati M. and Chawla, H.S. 2011. Sui generis IPR laws vis-à-vis farmers' rights in Asia and their implications under WTO. J Intellec. Prop Rights 16 (2): 107-116.

Chakraborty, S.K., Prakash, S., Sharma, S.P. and Dadlani, M. 2007. Testing of distinctiveness, uniformity and stability for variety protection. Division of Seed Science and Technology, Indian Agricultural Research Institute, New Delhi.

Chapter -11
Constitution, conduction and recording data in national/international nurseries
Charan Singh, Arun Gupta and Venkatesh K

National nurseries

The below mentioned nurseries are the national nurseries as they are constituted at ICAR-IIWBR, Karnal by contributed breeding materials by the breeders. National nurseries are being shared to the AICW&BIP cooperating centres to enrich their genetic diversity and making in-situ selection for the target traits or use as donors for hybridization.

National Genetic Stock Nursery (NGSN)

National Genetic Stock Nursery (NGSN) is considered as "suggested crossing block" and is constituted with the objective to provide genetic stocks and new germplasm for yield components, disease resistance and quality traits to the cooperating centres under AICW&BIP for utilization in wheat improvement programmes. The NGSN comprising number of lines comprising *T. aestivum* and *T. dicoccum* was provided to the different centres. The bread wheat entries were categorized as disease resistant, elite lines from NGSN, new agronomic bases and yield component lines and Karnal bunt resistant genetic stocks. *T. dicoccum* entries represented disease resistant stocks.The nursery was conducted in augmented design with two checks. An infector row was also included for observing disease incidence. The data were recorded on yield component traits, days to heading, days to maturity, plant height (cm), tillers/m, grain number/spike, 1000-grains weight (g) and spike length (cm).

Response of genotypes against various rusts and foliar diseases is an important component of NGSN screening and utilization. Disease reaction for yellow, black and brown rust was recorded at respective centres. Based on highest reactions and ACI, genotypes exhibiting resistant response under natural conditions were identified. Leaf blight data from hot spot locations has to consider for identification of resistant sources. All the bread wheat entries and checks were also analysed for processing quality parameters viz., test weight (kg/hl), protein content (%), sedimentation value (ml), grain hardness index as well as nutritional quality parameters like iron and zinc content (ppm). Promising genotypes for various traits has to identify for further utilization in wheat improvement programmes. The utilization report was received from centres and pooled utilization report indicated overall % utilization of entries in various breeding programmes.

Short Duration Screening Nursery (SDSN)

The Short Duration Screening Nursery (SDSN) comprising genotypes and was conducted in number of location in across the country. The aim of the nursery was to identify early maturing genotypes for terminal heat tolerance during grain filling period under late sown conditions. The nursery was conducted in augmented design. The test entries were contributed by respective wheat breeding centres. Data were recorded for days to heading, days to maturity, grain number per spike, 1000-grains weight (g) and yield per plot (g). The data pooled zone wise for analysis for various traits in order to identify promising lines for specific zone. Based on the pooled mean for earliness and yield, the promising genotypes showing better performance over the best check were identified.

Drought Tolerance Screening Nursery (DTSN)

The Drought Tolerance Screening Nursery was conducted to identify wheat genotypes for tolerance to moisture stress throughout the crop period. The nursery has to be sown both under drought and irrigated conditions with at least two replications. For drought conditions, the crop

was sown with pre-sowing irrigation only. For irrigated conditions recommended package of practice was followed. The minimum days for 75% heading of the genotypes at respective locations were considered for explaining intensity of stress before and after heading. Mean of minimum and maximum temperature and rainfall before heading were recorded at the centres. In order to identify the genotypes less sensitive to drought conditions, drought sensitivity index (DSI) was calculated for each location. Genotypes having DSI value less than 0.5 were considered as less sensitive to drought.

Salinity-Alkalinity Tolerance Screening Nursery (SATSN)

Salinity and or alkalinity have become a major edaphic problem for wheat cultivation as it significantly affects the overall productivity and production. Over-exploitation of underground water is increasing the problem of soil salinity in irrigated areas. A large portion of salt-affected land in India is cultivated by small and marginal farmers with limited resources to practice soil amelioration package, thereby limiting the crop output. Use of salt tolerant varieties would significantly improve the productivity of wheat in such areas. With an aim to identify suitable wheat lines that can perform better under saline and alkaline soils the Salinity-Alkalinity Tolerance Screening Nursery need to be constituted. The soil status of different centres has to be analyze as the soil of most of the centres are sodic in nature having high pH. The nursery comprising test entries obtained from different wheat breeding centres of the country are being evaluated along with suitable checks in augmented block design. On the basis of pooled analysis genotype was identified as highest yielding entry under saline and alkaline soils.

Segregating Stock Nursery (SSN)
The Segregating Stock Nursery (SSN) constituted with the objective to share promising segregating material with upcoming wheat breeding centres of AICW&BIP to enable them to evaluate and select superior plants as per the breeding objectives and cultural conditions prevailing under agro-climatic conditions. The nursery consisted of number of segregating populations (F_2/F_3) including material from rice-wheat programme, warmer area programme, leaf blight programme and durum wheat programme of IIWBR, Karnal. The nursery was supplied to wheat breeding centres. Data and utilization report from the conducting centres need to be received. The utilization report indicated maximum utilization of the nursery across the centres.

Quality Component Screening Nursery (QCSN)
The nursery was conducted at number of places to identify new genetic resource for quality improvement. Grain quality analysis was done at Karnal and the parameters involved were grain protein content at 14% grain moisture level, test weight (hectolitre weight), sedimentation volume, grain appearance score and grain hardness index. To identify promising genotypes, comparison has to be made against recently identified genetic resources and superior checks. Superior genotypes will be identified for individual quality components. Disease incidence and utilization report has to be submitted by the cooperating centres. The superior genetic resources for quality traits may be identified by this nursery.

Elite International Germplasm Nurseries (EIGN)
The elite international germplasm nursery (EIGN) is constituted every year and shared with cooperating centres with the objective to provide exotic germplasm for utilization in on-going breeding programme. The lines included in EIGN are selected based on superior yield performance and resistance to diseases during previous year's evaluation conducted at various locations across the country. EIGN comprised, exotic germplasm received from CIMMYT,

Mexico and ICARDA, Syria in the form of International nurseries and trials. The EIGN was constituted and supplied to the centres located across the zones. While selecting material for this nursery, it was ensured that material should be diverse, high yielding and disease resistant, so that these can cater to the needs of wheat researcher across the country.

The genotypes were evaluated in augmented design with recently released varieties as check of each zone (NWPZ, NEPZ, CZ and PZ). All the genotypes were also analysed for processing quality parameters *viz.* test weight, protein content, grain hardness index, moisture content & sedimentation value and also for nutritional quality parameters like iron & zinc content at the institute. Data has to be collected from all the locations and the pooled data were analysed to find out the promising genotypes for each trait.

Response of lines against yellow rust, black rust, brown rust and leaf blight has to be recorded under field conditions. The promising genotypes showing resistances under field condition across the locations need to be identified. The feedback report of EIGN indicates that breeders selected the genotypes from this nursery for various purposes. All the lines were analysed for processing quality parameters viz. test weight, protein content, grain hardness index, moisture content & sedimentation value and also for nutritional quality parameters like iron & zinc.

National Durum Screening Nursery (NDSN)

The National Durum Screening Nursery (NDSN) comprising lines selected from various international durum nurseries. The NDSN was evaluated in augmented design high yielding varieties as checks. The nursery was planted at number of locations and data need to be received from the centres. Genotypes showing promise for early maturity, number of tillers per plant, 1000-grains weight, spike length and grains per spike need to be identified zone wise and across the zones. Response of lines against black rust, brown rust and yellow rust has to be recorded under field conditions. The feedback reports of NDSN usefulness of the nursery.

Table 1: Traits to be recorded in different national nurseries

SN	Nursery	Traits	Additional
1	NGSN	DH, DM, TPM, GPS, TKW, SpL and Diseases (Yr, Lr, Br, LB, PM); Quality: TW, Protein, Sed. Val. GrHard. Zn and Fe	Utilization report
2	SDSN	Yield, DH, DM, GPS and TKW	
3	DTSN	Yield and DSI	Weather parameters
4	QCSN	TW, Protein, Sed. Val. GrHard. Gr Appearance score, Zn and Fe	
5	SATSN	Yield, DH, DM, GPS and TKW	
6	EIGN	Yield, TKW, TPM, GPS, Yr, Lr, Br, LB Quality: TW, Protein, Sed. Val. GrHard. Zn and Fe	
7	NDSN	Yield, TKW, TPM, GPS, Yr, Lr, Br, LB Quality: TW, Protein, Sed. Val. GrHard. Zn and Fe	
8	SSN	-	Utilization report

International Nurseries and Trials

The Indian Institute of Wheat and Barley Research, Karnal obtain wheat germplasm from CIMMYT, Mexico in the form of international nurseries and trials in order to enrich the ongoing breeding programmes in our country. The various trials and nurseries were evaluated at various locations and spread across the country. It provides an opportunity to the co-operators to select desirable lines for utilization in their breeding programmes. One set of each

nursery/ trial has to be planted at IIWBR, Karnal in order to facilitate large number of wheat breeders/pathologist of the country for exercising *in-situ* selection as per their requirement.

International nurseries and trials are being served the below mentioned objectives,
➢ To provide wheat researchers with an opportunity to assess the yield performance of advanced breeding lines over a wide range of production conditions
➢ To provide needed information on adaptation
➢ To enable researchers in national crop improvement programs

During crop season 2019-20, 07 CIMMYT trials including one durum wheat and 7 CIMMYT nurseries including 01durum wheat were received. While 04 trials wheat including 01durum wheat and 03 nurseries including 01durum wheat were received from ICARDA (Table 2).

Table 2: International Trials/Nurseries received during 2019-20

CIMMYT		ICARDA	
Trials	**Nurseries**	**Trials**	**Nurseries**
ESWYT	IBWSN	ESBWYT	DSBWON
HRWYT	SAWSN	HTSBWYT	HTSBWON
HTWYT	STEMMRSN	DSBWYT	IDON
SAWYT	IDSN	IDYT	
IDYN	HRWSN		
WYCYT	HLBSN		
SATYNDRGHT	KBSN		

The expended forms of International trials and nurseries are as below:
CIMMYT Trials: ESWYT: Elite Spring Wheat Yield Trial, HRWYT: High Rainfall Wheat Yield Trial, HTWYT: High Temperature Wheat Yield Trial, SAWYT: Semi-Arid Wheat Yield Trial, IDYN: International Durum Yield Trial, WYCYT: Wheat Yield Consortium Yield Trial and SATYNDRGHT: Stress Adaptive Trial for yield under drought.
ICARDA Trials: ESBWYT: Elite Spring Bread Wheat Yield Trial, HTSBWYT: Heat Tolerant Spring Bread Wheat Yield Trial, DSBWYT: Drought Spring Bread Wheat Yield Trial and IDYT: International Durum Wheat Yield Trial

CIMMYT Nurseries: IBWSN: Int. Bread Wheat Screening Nursery, SAWSN: Semi-Arid Wheat Screening Nursery, STEMMRSN: Stem Rust Resistance Screening Nursery, IDSN: International Durum Screening Nursery, HRWSN: High Rainfall Wheat Screening Nursery, HLBSN: Helminthosporium Leaf Blight Screening Nursery and KBSN: Karnal Bunt Screening Nursery
ICARDA Nurseries
DSBWON: Drought Tolerant Spring Bread Wheat Observation Nursery HTSBWON: Heat Tolerant Spring Bread Wheat Observation Nursery and IDON: International Durum Wheat Observation Nursery

Traits to be recorded: The following trait needs to be recorded for the different trials and nurseries;

SN	Nursery	Traits
1	CIMMYT Trials	Heading, Height, Lodging, Grain-Yield, 1000-Kernel wt, Agronomic-Score, Disease
2	ICARDA Trials	Heading time, Maturity time, Plant height, Stripe rust, Leaf rust, Stem rust, Agronomic score, Grain yield, Grain weight

3	CIMMYT Nurseries:	Heading, Height, 1000-Kernel wt, Agronomic-Score, Leaf-Rust, Stem-Rust, Yellow-Rust, Septoria-tritici, other disease
4	ICARDA Nurseries:	Heading, Maturity, Plant height, Stripe rust, Leaf rust, Stem rust, Agronomic score, Grain yield, Grain weight

A wheat field day is being organized probably in the month of March at ICAR-IIWBR, Karnal, wherein wheat breeders/pathologist from various co-operating centres is being participated. The list of material selected by the breeder/pathologist has to submit to the PI, Crop Improvement. Later on seeds of the selected material are being provided to them. Apart from this, duly filled data booklets were received from most of the centres and these served as a feedback reports from centres. Based on yield *per se* under different agro-climatic conditions and yield contributing traits like early heading, maturity period, height, promising lines are being identified for various zones as well as across the zones.

The data of various yield trials from different centres was compiled and on the basis of the yielding ability of various germplasm lines, the lines showing superiority over the check varieties were identified. The field screening for multiple diseases were also conducted. The lines which recorded resistant reaction to various diseases under field condition are being identified from some of the trials/ nurseries. Further, promising lines identified from various trials/nurseries for yield *per se*, grain weight, early heading and possessing resistance to rust will be included in Elite International Germplasm Screening Nursery (EIGN) that would be constituted during the forthcoming wheat season for further evaluation and selection by the co-operators. The promising lines that exhibited numerically higher or at par disease score over the checks were identified for various zones as well as for across the zones of the country.

Sowing time of yield trials in different zones

Trial Series	NHZ	NWPZ	NEPZ	CZ	PZ
AVT-IR-TS-TAS	Nov. 1-15	Nov. 1-15	Nov. 15-25	-	-
AVT-IR-TS-TAD	-	-	-	Nov. 10-20	Nov. 5-15
AVT-IR-LS-TAS		Dec. 10-25	Dec. 15-25	Dec. 5-15	Dec. 1-10
AVT-RF-TS-TAS	Oct. 15-31	-	Oct. 25-Nov.10	-	-
AVT-RF-TS-TAD	-	-	-	-	Oct. 15-31
AVT-RI-TS-TAS/TAD	-	Oct.25-Nov.5	Oct.25-Nov.10	Oct. 25 - Nov.10	Oct. 25 - Nov.10
AVT-RF-ES-TAS	Oct. 1-10	-	-	-	-
AVT-RI-LS-TAS	Dec. 1-15	-	-	-	-
NIVT-1A-IR-TS-TAS	-	Nov. 1-15	Nov. 15-25	-	-
NIVT-1B-IR-TS-TAS	-	Nov. 1-15	Nov. 15-25	-	-
NIVT-2-IR-TS-TAS	-	-	-	Nov. 10-20	Nov. 10-20
NIVT-3A-IR-LS-TAS	-	Dec. 10-25	Dec. 15-25	-	-
NIVT-3B-IR-LS-TAS	-	-	-	Dec. 5-15	Dec. 1-10
NIVT-4-IR-TS-TDM	-	-	-	Nov. 10-20	Nov. 5-15
NIVT-5A-RI-TS-TAS	-	Oct.25-Nov. 5	Oct.25-Nov.10	Oct. 25-Nov. 10	Nov.1-10
NIVT-5B-RI-TS-TDM	-	-	-	Oct. 25-Nov. 10	Oct. 25 - Nov.10
IVT-RF-TS-TAS	Oct. 15-31	-	-	-	-
IVT-IR-TS-TAS	Nov. 1-15	-	-	-	-
SPL-IR-TS-Dicoccum	-	-	-	-	Nov. 1-15

Norms for conduction of yield trials

1. The name and parental details of NIVT/IVT and Special trial entries once submitted and finalized in the workshop will not be changed.
2. The test sites of all trials and entries including the checks finalized in the workshop should not be changed.
3. Date of sowing should be strictly adhered to as given in the planting details supplied with the layout plan of different trials.
4. Seed rate and plot size should not be changed.
5. Plot border rows of the trial entries should be excluded during harvesting for reporting the net plot yield.

Norms with respect to site mean and coefficient of variation (CV) for acceptance or rejection of coordinated yield trials

Minimum limit of site mean (Yield in q/ha)

Zone/Trial	Timely sown irrigated condition	Late sown irrigated condition	Timely sown restricted irrigated condition	Timely sown rainfed condition
NHZ	30	20	-	15 (Also for early sown rainfed)
NWPZ	45	35 VLS = 25	30	-
NEPZ	40	30 VLS = 20	25	-
CZ	40	30	25	-
PZ	40	30	25	15
Salinity/ Alkalinity	20	-	-	-
Dicoccum	30	-	-	-

Maximum limit of coefficient of variation (CV)

Production condition	Maximum limit
Irrigated condition (Timely or late sown)	15%
Restricted irrigated condition	20%
Rainfed condition (Timely sown)	25%
Salt affected condition	25%

Criteria for Promotion/Retention of Varieties in the Coordinated Wheat Varietal Trials

The varieties qualifying for promotion/retention, besides being high yielding as compared to the best check varieties (including latest identified variety), should possess adequate degree of resistance to rusts and other diseases of regional importance and good nutritional and processing qualities. The following criteria are followed to achieve these objectives.

(I) Yield

Varieties which are significantly superior at 10% level of statistical significance to best performing check of the trial in AVT and best zonal check in NIVT/IVT will be considered for promotion/retention.

(II) Resistance to diseases

(A) Rusts

Varieties qualifying from yield point of view must have adequate degree of resistance to rusts under both natural as well as artificial conditions of infection.

The average coefficient of infection (ACI) for each of the rusts of importance in the particular zones should be considered in respect of varieties qualifying in yield criteria. Important rusts in each zone are as follows:

NHZ & NWPZ : Yellow and Brown
NEPZ : Brown
CZ & PZ : Brown and Black

When data of rusts from centres is not sufficient to calculate ACI, the intensity of susceptibility to rusts should be considered.

Varieties having reaction marked with an asterisk should be given benefit of doubt for susceptibility to that particular rust and thus should be considered suitable for promotion/retention.

(i) Under natural conditions of rust infection (In coordinated varietal trials)

a) ACI upto 15.0

b) Maximum, susceptibility should be considered if ACI could not be worked out. It should not be more than 40S.

c) Varieties with higher susceptibility but marked with asterisk should be given benefit of doubt and therefore not to be rejected on this account.

d) For NEPZ, susceptibility to yellow rust is limited to 40S under natural condition and/ or ACI 25.0 in PPSN.

(ii) Under artificial conditions of rust infection (in plant pathological screening nurseries).

a) ACI not more than 20.0 for varieties meant for irrigated condition and not more than 25.0 for varieties meant for rainfed condition.

b) If ACI is not worked out, maximum susceptibility should not exceed 30S both in case of varieties meant for irrigated and rainfed conditions.

c) Benefit of doubt to be given to varieties with higher degree of susceptibility but marked with an asterisk.

(B) Other diseases

Due weightage should be given to other diseases of regional importance such as *leaf blight for NEPZ and Karnal bunt for NWPZ* and varieties with extreme susceptibility shall be avoided from advancement/retention.

(Ill) Quality

Varieties qualifying for yield and disease resistance criteria should have at least 10% protein on dry matter basis. Any such variety having less than 10% protein should not be retained/promoted.

Disease Criteria for Promotion/Retention of Varieties

Varieties qualifying for yield	Reaction to rusts of importance in the zone					
	ACI value available		ACI not available		Varieties having higher readings but marked with asterisk	
	Natural conditions	PPSN	Natural conditions	PPSN	Natural conditions	PPSN
Varieties significantly superior in yield to the best check	Upto 15.0	Upto 20.0 for irrigated varieties & upto 25.0 for rainfed varieties	Upto 40S	May be ignored	To be retained/ promoted	To be retained/ promoted