# Three Decades of NARC-CIMMYT Partnership in Maize and Wheat Research and Development

*(1970-2000)*

**Nepal Agricultural Research Council (NARC)**
and
**International Maize and Wheat Improvement Center (CIMMYT)**
**Nepal**
**February 12, 2001**

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National Wheat Research Program, Bhairahawa
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# Foreword

It gives me a great pleasure to publish this booklet on the occasion of NARC-CIMMYT Day to mark Three Decades of NARC-CIMMYT Partnership in Maize/Wheat Research and Development. Both maize and wheat are priority cereal crops for food security in Nepal. During thirty-year period, noticeable progress has been made in the field of maize production. The importance of maize has increased substantially in Nepal in the past thirty years with area and production nearly doubling. Currently, maize occupies an area of 8,24525 ha. with an average yield of 1.8 t/ha. Our research has shown that this productivity of maize can be trebled in favorable areas and can be doubled in marginal areas. We would further like to extend this partnership for appropriate technology generation and dissemination for increased productivity that it further contributes to food security and poverty alleviation. The quality protein maize (QPM) developed by CIMMYT has a far reaching impact in fighting malnutrition and low protein diet of Nepalese hill people. NMRP has made its programme to take up hybrid maize research and development for terai and inner terai as an irrigated winter and spring crop and OPVs for mid hills. I hope, a strong collaboration between NARC and CIMMYT in QPM and hybrid maize research would be forthcoming in the future.

A remarkable progress in wheat production during the three decades of NARC-CIMMYT partnership has been achieved with more than six fold increment in wheat areas and ten fold increment in production. Now, wheat is grown in 6,60,040 ha. compared to 1,00,000 ha. in 1960s.The production is 11,83,530 mt. in contrast to about 1,00,000 tonnes in 1960s. Wheat faces stiff competition with other winter crops like legumes, oilseed, winter maize and vegetables etc. Despite all these, it is a very important crop in our country. The present productivity is 1.793 t/ha and it can be doubled with judicious use of inputs and other related technologies.

One of the strategies in wheat is to mechanize its cultivation in terai/inner terai and accessible valleys for reduced cost of production. The future collaboration between NARC and CIMMYT in wheat research will focus to solve this problem. Another area where scientists should look into, along with increasing productivity, is reduction of cost of production so that wheat cultivation becomes a remunerative enterprise.

In the post-green revolution period elsewhere in the region, Nepal is also experiencing wheat stagnation due to soil fatigue and degradation of natural resource base.

Finally , I congratulate the scientists of Nepal who have been working to bring the production of maize and wheat at the present level and I sincerely thank the effort of CIMMYT to help us in our endevour to fight against poverty and malnutrition.

Dhruva Joshy
Executive Director
Nepal Agricultural Research Council

# Three Decades of Achievements Through NARC-CIMMYT Partnership in Maize Research and Development



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## 1.0 Maize in Nepal - an Overview:

Maize is the second most important staple food crop after rice in Nepal. Furthermore, the importance of maize in Nepal has increased substantially in the past 30 years with maize area and production nearly doubling (Figure 1). Maize is currently grown on 8,24,525 ha of land with an average yield of 1.8 tons $ha^{-1}$. Maize is primarily used for human food. Nevertheless, the importance of maize grain as an animal feed is increasing rapidly, particularly in areas of the country that have good road and market access. Maize stover is also an important source of roughage for livestock in mixed animal/crop farming system where maize is grown.

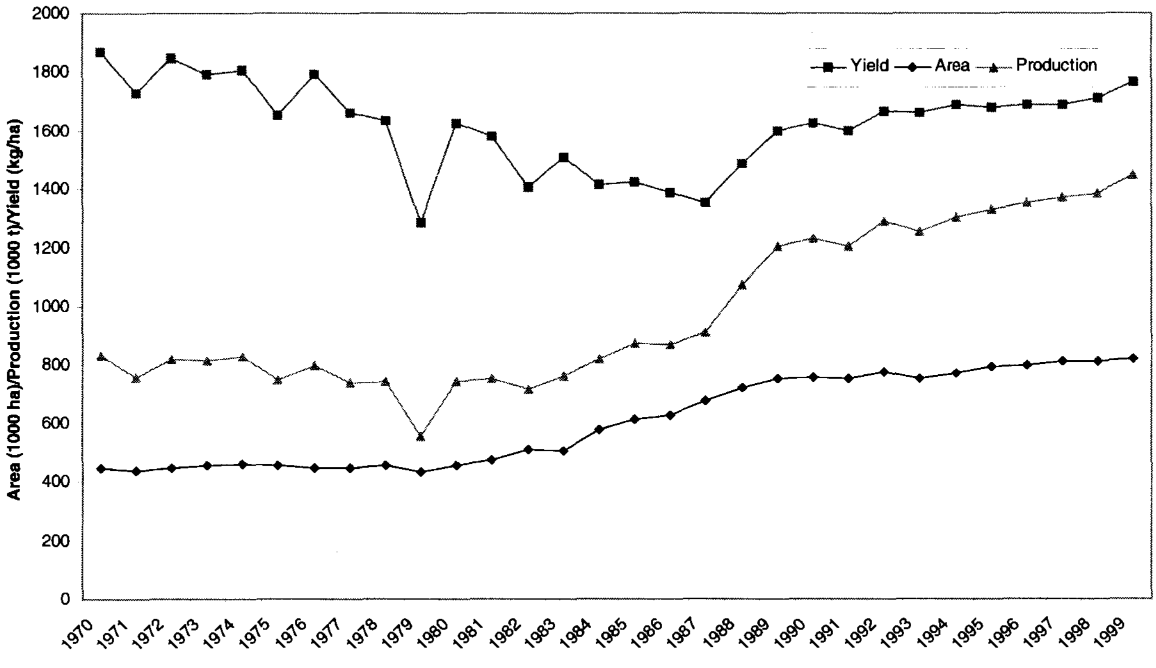



**Figure 1. Maize area, production and yield over the period 1970-1999.**

Maize is produced in three rather distinct agro-climatic zones within Nepal, the Terai and Inner-Terai (below 900 m), the mid-hills (900-1800 m) and the high-hills (above 1800 m). The greatest area of production (70%) is in the mid-hills, followed by the Terai (22%) and the high-hills (8%). Although maize area and production have grown substantially over the past 30 years, maize yield has been more or less static at less than 1.8 t $ha^{-1}$. During the next two decades the overall demand for maize in Nepal is estimated to grow by 6-8% per annum, largely as a result of the increased demand for food in the hills as population increases and for livestock feed in accessible areas in the Terai and Inner-Terai as the demand for milk, meat and meat products grows. Future production increases must come from increased productivity in maize-based systems, as there is little opportunity for further expansion of cultivated area. Agriculture Perspective

Plan (APP) and the current Nepalese Five-Year Plan has given high priority to the development of agriculture in the hills, and an increase in maize yield per unit land area is an essential component of this. The growth in the use of maize grain as animal feed and for other industrial products is now at 10-15% per annum, particularly in Terai, Inner Terai and urban areas. Currently, the average per capita maize consumption is 61 kg/year and only 2% of the grain produced is used for animal feed (CIMMYT, 1997/98).

## 2.0 Maize Research in Nepal

### 2.1 Historical Background

Systematic efforts in maize (*Zea mays L.*) research commenced with the inception of the maize program within the Division of Agricultural Botany (DOAB), Khumaltar in 1965. The Maize Program was developed with advice from Dr. E.W. Sprague, the then Coordinator of the Rockefeller Foundation's Maize Development Program for South East Asia (Rajbhandary, 1982). The main objective of the maize program in Nepal was to identify and develop high yielding varieties adapted to the different agro-climatic conditions of the country. Soon after the inception of the maize program at Khumaltar, exotic varietal crosses and composites were obtained from Inter-Asian Corn Program (IACP), in India. These IACP varietal trials were tested at Khumaltar, Rampur, Kakani and Nepalgunj. Three composite varieties, Rampur Yellow (Composite J-1) for the lower elevations (Terai and Inner Terai), Khumal Yellow (Antigua G2D X Guatemala) for the mid hills, and Kakani Yellow (Antigue G2 x Guatemala) for higher elevations performed extremely well and were officially released in 1966 in order to meet the growing demand for improved varieties. Within a very short period, these newly released varieties became very popular among farmers (Sharma and Lal, 1986).

In the early seventies nationally coordinated commodity programs for the major crops, rice, maize and wheat were initiated as stipulated in the Ten Year Agricultural Development Plan of HMG/N. The National Maize Development Program (NMDP) was established in 1972 at Rampur, Chitwan, as the lead institute to generate improved production technologies of maize and to achieve food security through improving research systems and building research capability. Over time, Nepal Agricultural Research Council (NARC) reassessed NMDP's research mandates and established the National Maize Research Program (NMRP) with a more focused mandate and objectives. Soon after this reorganization, the amount of maize research being carried out increased substantially. Collaborative links with the maize program of the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and other institutions were also established at that time. The objective of this collaboration was to improve and broaden the germplasm base used in the breeding and selection programs of NMRP through the introduction of exotic material. From the very beginning, the main objective of the maize program has been to develop high yielding and stress tolerant varieties suited to the major agro-ecozones and sociocultural situation of the country.

### 2.2 Current Structure and Objectives of NMRP

The National Maize Research Program (NMRP), based at Rampur in the Inner-Terai and administered under NARC, has the national mandate for maize research and improvement throughout the country. It operates its research and source seed multiplication program through the network of NARC research stations throughout the country. Maize research in the hills is concentrated at Lumle (LAC), Pakhribas (PAC), Kabre, Khumaltar, Ginger Research Program (GRP), Kapurkot and Agriculture Research Station (ARS), Surkhet. In addition to on-station research, each ARS has a command area of several districts where on-farm research is conducted by out-posted staff of the ARS through a network of sites.

In 1998 NMRP began the implementation of the Hill Maize Research Project in collaboration with CIMMYT with SDC funding. The objectives and the activities are focused on increasing the productivity and sustainability of maize crop especially in the hills. The project aims to address two broad objectives, as follows:

1. Increase food security of farm families in hill areas by raising the productivity and sustainability of maize-based cropping systems in the hills. This will be accomplished largely through:

a) The development and dissemination of improved maize varieties specifically adapted to hill environments, and through the development and promotion of resource-conserving productivity-enhancing crop management practices for maize-based systems, appropriate to farmers' circumstances and compatible with existing cropping and livestock systems.

b) Reduction in crop losses due to drought, low fertility, diseases and pests (including post-harvest insects and ear rots) through focused breeding efforts and integrated pest management (IPM) approaches (mainly host plant resistance).

2. Build sustained research capacity in the National Maize Research Program, NARC Agricultural Research Stations, and in allied institutions, and enhance the linkage between technology generation/verification and its delivery to farmers. The focus here will be particularly on the delivery of seed of improved varieties and the validation and promotion of management options in a participatory manner in farmers' fields.



## 3.0 CIMMYT's Maize Program and NARC-CIMMYT Collaboration

CIMMYT is an internationally funded, nonprofit scientific research and training organization, with the objective of improving the productivity, profitability and sustainability of maize and wheat systems for poor farmers in developing countries. CIMMYT has collaborated with Nepal on maize research primarily through its maize program, which is headquartered in Mexico. The maize program has several breeding programs that focus on developing maize genotypes for the major maize growing ecologies in the world. In addition there are regional programs that focus on developing genotypes with traits that are needed in that particular region. NMRP has collaborated with the breeding programs in Mexico, with CIMMYT-Zimbabwe and with CIMMYT's Asian Regional Program in Thailand.

NMRP has received a range of diverse CIMMYT germplasm and some of this germplasm has been found to be well adapted to the different environments of Nepal. Germplasm has been introduced since 1970 through the following international trials: **IPTTs, EVTs, ELVTs, Pools, Populations, inbred lines and hybrids** from CIMMYT, Mexico and regional programs in Africa and Asia. These materials were tested and selected genotypes were advanced directly or were introgresed with local materials including land races. Crosses have also been made between CIMMYT and local materials and superior varieties selected and advanced from these combinations.

## 4.0 Important Achievements of NMRP/CIMMYT Collaborative in Nepal

### 4.1 Varietal Releases

Within Nepal a number of high yielding maize varieties have been developed and released to farmers. In most cases germplasm provided by CIMMYT formed a significant component of these varieties. Out of the 15 varieties so far released, 10 varieties contain CIMMYT germplasm and are highly popular among farmers. Table 1 lists the varieties that have been released in Nepal and some of their basic characteristics and adaptation.

Of the currently released varieties, there are five which are widely grown by farmers which were developed with extensive use of germplasm from CIMMYT.

**Arun – 2 :**

- Most popular short season yellow variety
- Highest seed demand
- Widely adapted to terai and hills
- Tolerates high densities
- Resists lodging
- Preferred for green cob sale
- Suitable for three crop sequential cropping systems
- Stable over locations and years.

**Table 1:** Characteristics of maize varieties improved & released, 1966-1997

| Varieties | Parentage | Germplasm source | Av. Yield t/ha | Maturity days | Recommend | |
|---|---|---|---|---|---|---|
| | | | | | Year | Areas |
| 1. Ganesh-1 | Pool 9A | CIMMYT | 3.5-5.0 | 175 | 1997 | High hills |
| 2. Arun-1 | Pool 15, Pop 30, Koirali (w) | CIMMYT, local | 2.5-3.5 | 90 | 1995 | TIT & hills |
| 3. Rampur-1 | Pool 23, 32, 19 & 31 Poza Rica 7425 | CIMMYT | 3.0-4.5 | 110 | 1995 | TIT |
| 4. Rampur-2 | Pool 1721 and 25 sel. Procoz, Rampur 7433 & Khumal 7633 | CIMMYT CIMMYT | 3.5-4.5 | 110 | 1989 | TIT |
| 5. Ganesh-2 | Pool 6, Amarillo del Bajio, Khumal 7633, Mezcla Amerillo | CIMMYT | 3.0-4.0 | 175 | 1989 | Hills |
| 6. Makalu-2 | Amarillo del Bajio, lowland tropical X corn belt dent | CIMMYT | 3.0-4.5 | 170 | 1989 | Hills |
| 7. Manakamana-1 | Synthesized from Pool 23, 32, 19 & 31, Etoblanco, Pozarica 7425, Rampur 7434 Maracacy 7530 | CIMMYT | 3.5-4.5 | 135 | 1986 | Mid hills |
| 8. Arun-2 | Uncac 242 X Phil.DMR = Amarillo 59 (Temp X Trop) | CIMMYT | 2.5-3.5 | 90 | 1982 | TIT & hills |
| 9. Janaki ** | Rampur 7434 (Blanco sub-tropical) | CIMMYT | 4.0-5.0 | 170 | 1978 | TIT |
| 10. Sarlahi seto,** | Phill. DMR-2 | IACP | 3.0-4.0 | 120 | 1978 | TIT |
| 11. Rampur comp. | DMR Version of Thai Composite # 1* | IACP | 3.0-4.5 | 110 | 1975 | TIT & MHs |
| 12. Hetauda comp. | Sel. Local landraces | - | 3.0-4.0 | 120 | 1972 | TIT |
| 13. Kakani yellow | Antigua G 2 | IACP | 3.0-4.5 | 180 | 1966 | High hills |
| 14. Khumal yellow | Antigua G 2 D | IACP | 3.0-4.5 | 130 | 1966 | Hills |
| 15. Rampur yellow | Composite, J-1 | IACP | 3.5-4.0 | 105 | 1966 | TIT |

* Composites of 36 germplasm from diverse sources including CIMMYT.
** Merged in Manakamana-1

**Rampur Composite:**

- Most popular full season yellow variety
- Stable variety over locations and years
- Widely adapted to terai and hills
- Downy mildew tolerant

**Ganesh-1**

- Only white-grained full-season high-yielding variety for the high hills
- Moderately resistance to leaf blight complexes
- Higher fodder yield with stay green characteristics
- Suitable for use in maize-potato production systems

**Ganesh – 2:**

- Full-season high-yielding yellow variety for the high hills
- Moderately resistance to ear rots in heavy rainfall areas of the high hills of Nepal
- Earlier than other high hills varieties
- Well adapted for maize-millet cropping systems
- Performs relatively well when grown in less fertile soils

**Manakamana-1**

- Broad genetic base
- Stable and high-yielding white-grained variety
- Adapted for the mid-hills
- Performs well in winter maize production in Terai

**Rampur-2**

- Downy mildew resistance variety for the Terai and inner Terai and Foot hill valleys.



### 4.2 Promising varieties and hybrids

By screening germplasm recently provided by CIMMYT a number of promising open-pollinated varieties and hybrids have been identified. These materials were provided by the subtropical, highland and lowland breeding programs in CIMMYT-Mexico, CIMMYT-Zimbabwe and CIMMYT-Thailand. Recently, HMRP initiated a research program to develop hybrid maize for the accessible areas of the Terai. CIMMYT has provided a wide range of hybrids for testing and has also availed the inbreds of the most promising hybrids. This collaboration has enable NMRP to reduce the amount of time needed for developing hybrids (and the inbreds that are used to constitute them) by many years. For a complete listing of materials provided by CIMMYT which look promising for use within Nepal see Annex 1.

### 4.3 Maize Source Seed Production & Dissemination:

The maintenance and seed production of Nepal's open pollinated varieties of maize are managed through three stages of seed multiplication namely breeder's seed, foundation seed and certified seed. The responsibility for maintaining the purity of breeder's seed, as long as the variety is in production, rest on NMRP breeders. The responsibility for producing foundation seed also rests with NMRP through open pollination in well-isolated plots away from any sources of pollen contamination. NMRP sells, primarily the targeted amount of FS to the Agriculture Input Corporation (AIC) as well as DOA/ADOs, projects, INGOs, NGOs, CBOs and private growers. The production of certified seeds is through progressive contract farmers in accessible areas of Terai and Hills of Nepal. The amount of seed sales during 1994-2000 is given in Table 2.

**Table 2:** Summary of On-Station Maize Source Seed Production, Sale, estimated Amount and Area on Improved Seed, 1994/2000

| Varieties | Breeder Seed, (tons) | Foundation Seed (tons) | Improved Seed Production (tons)* | Estimated Area under improved seed (ha) | Rank Order |
|---|---|---|---|---|---|
| Rampur Composite | 3.7 | 59.8 | 2992.0 | 149600 | II |
| Arun – 2 | 2.1 | 85.9 | 4296.0 | 214800 | I |
| Manakamana- 1 | 0.5 | 13.6 | 680.7 | 34055 | III |
| Khumal yellow | 0.4 | 11.6 | 577.6 | 28867.5 | IV |
| Arun-1 | 0.4 | 5.7 | 284.1 | 14202.5 | V |
| Rampur-2 | 0.3 | 2.2 | 109.5 | 5475 | |
| Rampur-1 | 0.3 | 0.8 | 39.5 | 1975 | |
| Ganesh-2 | 0.4 | 1.7 | 83.6 | 4167.5 | |
| Ganesh-1 | 0.1 | 1.5 | 74.0 | 3700.0 | |
| Arun-4 | 0.4 | 1.9 | 95.0 | 4750.0 | |
| Manakamana-2 | 0.3 | - | | | |
| Hill Pool (W) | 0.1 | - | | | |
| Hill Pool (Y) | 0.1 | - | | | |
| Total | 9.1 | 184.7 | 9232.0 | 461592.5 | |

* 1.0 ton improved seed (IS) yield is estimated from 1 ha FS field. Frequency of replacement of improved maize seed by Nepalese hill farmers is assumed to be six year

According to the published statistics 65 percent of the maize cultivated in Nepal is covered by improved genotype mainly Arun 2, Rampur Composite, Manakamana 1 and Arun 1. The amount of foundation and improved seed produced over the period of six years also correspond to the area coverage under improved seed. As maize seed deteriorates rapidly in the farmers growing circumstances, the advantages of improved genotypes can be translated to more production only when fresh seed is made available to farmers regularly. To tackle this problem HMRP has already initiated community based seed production where farmer groups produce their own quality seed under the technical guidance of CIMMYT/NMRP through ARSs operating under NARC. The surplus seed is marketed in the adjoining areas and beyond as seed producing groups gain confidence and skills as seed entrepreneurs. Given the poor market linkages between villages in the hills the emphasis in the future will be on supporting a large number of relatively small production enterprises so that seed will be more readily available to more farmers.

### 4.4 Better Research Targeting

A GIS-based Maize Almanac for Nepal was developed in 1999 and early 2000 under the leadership of the GIS lab in CIMMYT-Mexico. A working version of the Almanac, which includes both software and databases, was released by CIMMYT in 2000. At that time most of scientists involved in HMRP activities and other key research managers were exposed to the potential uses of this tool and were trained in its use.

Rapid Rural Appraisals (RRAs) were conducted throughout the maze growing regions of Nepal in 1999, with technical guidance from CIMMYT's maize and economics programs. These data, combined with geographical and climatic data were used to establish priorities for research in 2000. A baseline survey of maize production practices was completed in 2000. These data will allow NARC to monitor the impacts of their various research endeavors.

Working group meetings on soil fertility and post-harvest management were held in order to better understand and document the research that has already been carried out and to agree upon a strategy for addressing these priorities within the project.

### 4.5 Crop Management Recommendations

#### Plant Population

Under normal soil fertility condition the optimum maize population for maximum yield is 55-65 thousand plants per hectare for a full season variety. Under monoculture and high fertility condition, short durations variety can produce higher yield under high plant population (up to 90 thousand/ha) with the spacing of 50x25 cm.

#### Foliage Removal Practices

There is a trade of between grain and fodder yield with regard to foliage removal practiced by the maize farmers. Adhikari (1990) concluded that up to 75% of the plant could be detasseled randomly before pollen shedding for fodder use. In large fields, random removal of tassels before pollination provides quality fodder for livestock and significantly increases maize yield. Farmer's practice of detopping after brown husk did not affect the grain yield. The leaf stripping including ear-bearing leaf showed detrimental effect on grain yield and thus should be discouraged in the maize mono-cropping system.

#### Nutrient response and time of fertilizer manure application

The fertilizer use efficiency depends on several factors, among them are physical and chemical properties of soil, crop variety, season, time of planting, soil moisture, cropping pattern, fertilizer sources and time and method of application.

The results of number of fertilizer experiments conducted at research stations and farmer's field showed the mean response of 12-20 kg maize grain per kg N. 60-90:30:30 NPK Kg/ha in combination with 10 ton/ha FYM is found to be optimum fertilizer recommendation for bariland maize in the hills of Nepal.

In maize growing soils of Chitwan valley, sulphur, boron and molybdenum are found to be deficient elements.

## Amount, time and method of fertilizer application

Balanced use, optimum doses, correct method, and right time of application of fertilizers ensures increased maize crop production. Maize is highly responsive to nitrogen fertilizer. Prasad (1978) recommended that application of N-fertilizer @ 80 kg/ha in two splits, i.e. 50% at the time of sowing as band placement and the remaining 50% at knee-high stage as side dressing produced the highest grain yield per kg N applied and was more efficient.

## Weeding and weed control

Yield loss as high as 80% was recorded in the absence of weed control and inter-culture operation. Experimental results have established that first weeding is very critical in summer maize. It was concluded that first weeding at 20-30 days after sowing and earthing up operation before tasseling is important for higher yield. Pre-emergence application of Atrazine-50 WP @ 3 g/lit of water produced the highest mean grain yield followed by post-emergence application of Atrazine plus one earthing-up operation.

## Baby Corn production technology

- Total edible baby ear shoot yield was found to be higher in winter-than summer at Rampur, Chitwan (Inner Terai/Siwalik Valley)
- The variety RAM-1, RAM-3 and RAM-4 were found superior OPVs for baby corn production in summer as well as in winter
- Higher plant density (130,000 plant/ha) produced high edible ear baby shoot irrespective of variety
- Baby corn production economics revealed that it is a cost-effective farming enterprise with the benefit cost ratio of 1.85 in summer and 2.19 in winter.

## Maize based Cropping systems

In the maize-millet relay system there is interplay of maize variety (short Vs long duration, Erect Vs lax leaf architecture) and planting time of millet as well as growing condition. The relaying of millet during reproductive phase of maize did not reduce maize yield.

In general maize-millet system is more productive compared to monocrop at the same time it could be exhaustive on soil nutrients. Regardless of maize genotypes, millet transplanted at 60 days after maize sowing did not reduce the maize yield. However direct sowing of millet at 20 days after maize sowing and transplanting at 30 days after maize sowing reduced maize yield.

Compost incorporated immediately after being carried into the field and plough treatment produced 54.2% and 46.3% higher yield of maize variety Arun-2 over compost exposed for 7 and 15 days respectively.

The early maturing, dwarf, determinate type of cowpea variety Prakash is a suitable crop, which, can be grown within the short duration of a fallow period. It fits well after early maize as a catch crop before planting mustard (Early maturing maize-cowpea- mustard) in Inner Tarai bariland condition.

With the establishment of the HMRP collaboration between CIMMYT and NARC on the generation of crop management practices was initiated. The collaborative effort is only two years old, there has not been sufficient time to develop and verify new crop management recommendations. Nevertheless, as a result of the work already completed, the following results are promising:

- The soybean variety CN-60 grows well as an intercrop of maize. The combination of maize intercropped with CN-60 produces superior returns to other intercrops and may be a viable option for extensive areas that are currently growing maize-millet combinations.
- Confirmation of the very important role that organic inputs have on the sustainability of the productivity of a maize-based system.
- Greater overall productivity is achieved with intercropping. Future research should focus on identifying species and varieties that are adapted to the heavy rains during the monsoons.

### 4.6 Strengthening the Capacity of the National Maize Program Through Collaboration

CIMMYT has been active in building the capacity of the NMRP since its inceptions. This has been accomplished through training at CIMMYT, visiting scientist programs, in-country training courses, networking and consultative visits of CIMMYT staff.

*Training at CIMMYT* – Since 1970, 43 maize researchers were trained in basic courses of maize improvement and production agronomy since in Mexico and in Kenya. (Annex 2).

*Visiting Scientist Programs* – During the same period, fifteen senior maize scientists were exposed to recent, advanced and updated maize research methodologies/technologies as visiting scientists (Annex 3).

*In-country Training Courses* – CIMMYT and NARC have collaborated on the implementation of a number of in-country training courses in Nepal. These include: Maize Breeding and Seed Production (Rampur and Lumle), Use of the Maize Almanac (Khumaltar), Training Trainers in Community-based Seed Production (Rampur) and Use of Computers in Statistical Analysis of Research Data.

*Networking* – NARC has actively participated in the regional network for Asia, TAMNET. This participation includes the evaluation of materials provided by other participating countries. CIMMYT has been active in facilitating the activities of TAMNET. A number of superior genotypes have been selected and used by NARC as a result of their participating in TAMNET. NARC scientist have also been able to participate in international conference, including the Regional Asian Maize Conference, which is routinely organized by CIMMYT, with the assistance of CIMMYT. CIMMYT currently coordinates a biotechnology network within Asia. The experiences from this network will be used as NARC expands into biotechnology issues in the future.

*Consultative Visits of CIMMYT staff* – CIMMYT staff from Mexico and the regional office in Thailand have made numerous visit to Nepal in order to provide technical assistance to the NMRP. During these visits, CIMMYT staff have helped in the selection of germplasm, provided one-on-one training on research methodologies and helped in establishing priorities for maize research.

## Annex 1.



**A. Promising full season open-pollinated varieties for the mid-hills**

| | | |
|---|---|---|
| 1- | TLALTIZAPAN 9544 | CIMMYT-Mexico |
| 2- | POP 45 C8 | CIMMYT-Mexico |
| 3- | POP 42 C8 | CIMMYT-Mexico |
| 4- | UDAIPUR 9433 | CIMMYT-Mexico |
| 5- | DRACOSYBF1/DRBC | CIMMYT-Mexico |
| 6- | [P501-SRCO-F1/...] | CIMMYT-Zimbabwe |
| 7- | ZM601-C4F23-## | CIMMYT-Zimbabwe |
| 8- | GRACE (EW1-2)-## | CIMMYT-Zimbabwe |
| 9- | ZM421 | CIMMYT-Zimbabwe |
| 10- | ZM521 | CIMMYT-Zimbabwe |
| 11- | S2SYNF2(GPLA)-# | CIMMYT-Zimbabwe |
| 12- | ZM 621 | CIMMYT-Zimbabwe |
| 13- | LATAC1F1/LATBC1F1 | CIMMYT-Zimbabwe |
| 14- | EV8766 | CIMMYT-Zimbabwe |

**B. Promising short-season open-pollinated varieties**

| | | |
|---|---|---|
| 1- | POOL - 15E | CIMMYT-Thailand |
| 2- | POOL- 17E | CIMMYT-Thailand |
| 3- | POOL-16C21/POOL-27 | CIMMYT-Thailand |
| 4- | Z97EWB | CIMMYT-Zimbabwe |
| 5- | Z97EWA | CIMMYT-Zimbabwe |
| 6- | EARLY-MID-1/KATUMANI | CIMMYT-Zimbabwe |
| 7- | ZM-301 | CIMMYT-Zimbabwe |
| 8- | POOL-27 | CIMMYT-Mexico |
| 9- | POOL-28 | CIMMYT-Mexico |

**C. Promising open-pollinated varieties for the high-hills**

| | | |
|---|---|---|
| 1- | SNSYNF1 (GCA) | CIMMYT-Zimbabwe |
| 2- | S2SYNKOT11/S2 | CIMMYT-Zimbabwe |
| 3- | [KIT/SNSYN(N3) ] | CIMMYT-Zimbabwe |
| 4- | [AC969-ASR(BES FS)]F1-# | CIMMYT-Zimbabwe |

**D. Promising normal grain type hybrids**

1- AMATALCOHS 115-1-2-3-3-1-2-BBB-1 X (24STES*24STE5*24STE-17)-BBBB-###-B-3-B-3-BBBBB
2- S.A.M.T.S.R.-23-3-2-3-2-BB-F-##-B x Varios-1-BBBBB x R-80-1-1-B-2
3- (CL00358*CL02713)-B-3-BBBBB x P31-C455B-39-##-BBB
4- SW92145-2P9S2-##-BBB x P22TSRC4-158-2-5-BB-5-BBBB
5- (24STE5*24STE-17)-BBBB-###-B-3-B-3-BBBBB x P345 C4S2-BB-46-1-1-2-2-BB
6- (SUWAN 5 (S) C3S2-76-2-4-1 x AMATLCOHS 207-1-3-1-1-1)-1-BB x (K144XTLxc3S5 147-2-2-3)-1-BB
7- (P28C7S5B-13-1-2-2-1 x CGHGS2-18-1-1-1)-1-BB x (AMATLCOHS 71-1-1-1-2-1-1 x AMATLCOHS145-1-1-1-4-1)-BBB
8- CML 78 X CML 216
9- CML 404 X CML 258
10- CML 78 X CML 373
11- CL 00368 X CML 287

**E. Promising QPM grain type hybrids**

1- CLQ G 2602 X CML 161
2- CML 161 X CML 165

**F. Promising inbred lines:**

1- Pop 345C4S2B-46-1-1-2-2-BBB
2- AMATLCOHS169-1-1-1-1-2-2-1-BBB
3- (Suwan 5 (S) C3S2-76-2-4-1 X Ki45)-BBB

# Annex 2.



## Participation of Nepalese as a Trainees on CIMMYT, Maize Program

| Name | From | To | Program-Especially |
|---|---|---|---|
| 1. Mathema, Brahmaram B. | April 27, 1971 | July 25, 1971 | Maize-Imp/Breeding |
| 2. Rajbhandary, Gopal | June 13, 1971 | July 31, 1971 | Maize-Imp/Breeding |
| 3. Regmi, Ishwari Raj | January, 13, 1973 | February 24, 1973 | Maize-Prod/Aron/CMR |
| 4. Karna, Arun Kishor | June 1, 1974 | December 1, 1974 | Maize-Imp/Breeding |
| 5. Lal, Kaushal Kishor | November 1, 1974 | June 1, 1975 | Maize-Prod/Aron/CMR |
| 6. Shivakoti, Gopal Prasad | February 1, 1975 | April 1, 1975 | Maize-Prod/Aron/CMR |
| 7. Mishra, Toya Nath | February 1, 1975 | April 1, 1975 | Maize-Prod/Aron/CMR |
| 8. Adikari, Basanta Prasad | February 1, 1975 | April 1, 1975 | Maize-Prod/Aron/CMR |
| 9. Baniya, Bimal Kumar | November 28, 1976 | May 15, 1977 | Maize-Imp/Breeding |
| 10.Shrestha, Keshab Prasad | December 3, 1976 | May 3, 1977 | Maize-Prod/Aron/CMR |
| 11.Chaudhary, Indu Bhushan | June 13, 1978 | November 7, 1978 | Maize-Imp/Breeding |
| 12.Koirala, Keshava Prasad | June 13, 1978 | November 7, 1978 | Maize-Prod/Aron/CMR |
| 13.Pandit, Bhubanchandra | September 18, 1978 | November 7, 1978 | Maize-Prod/Aron/CMR |
| 14.Sharma, Radha Raman | September 18, 1978 | November 7, 1978 | Maize-Prod/Aron/CMR |
| 15.Shrestha, Shova Kumar | September 18, 1978 | November 7, 1978 | Maize-Prod/Aron/CMR |
| 16.Dahal, Kashi Nath | November 29, 1979 | May 17, 1980 | Maize-Prod/Aron/CMR |
| 17.Adhikari, Krishna | November 29, 1979 | May 17, 1980 | Maize-Prod/Aron/CMR |
| 18.Briksh, Ram Prasad | November 1, 1981 | May 1, 1982 | Maize-Prod/Aron/CMR |
| 19.Upreti, Ram Prasad | November 1, 1981 | May 1, 1982 | Maize-Prod/Aron/CMR |
| 20.Upadhayay, Hari Krishna | May 27, 1983 | November 30,1983 | Maize-Prod/Aron/CMR |
| 21.Batsa, Binaya Kumar | May 27, 1983 | November 22,1983 | Maize-Prod/Aron/CMR |
| 22.Srivastava, Surendra Prasad | May 24, 1985 | November 15,1985 | Maize-Prod/Aron/CMR |
| 23.Sharma, Divakar | May 24, 1985 | November 15,1985 | Maize-Prod/Aron/CMR |
| 24.Shrestha, Krishna Kumar | June 7, 1986 | November 26,1986 | Maize-Prod/Aron/CMR |
| 25.Palikhe, Mahesh Man | February 25, 1987 | July 31, 1987 | Maize-Imp/Breeding |
| 26.Pradhan, Gopal | September 23, 1987 | March 8, 1988 | Maize-Experiment/station |
| 27.Paudel, Dilip Chandra | March 2, 1988 | July 26, 1988 | Maize-Imp/Breeding |
| 28.Chaudhary, Bedanand | August 31, 1988 | January 14, 1989 | Maize-Prod/Aron/CMR |
| 29.Gauchan, Devendra | March 4, 1990 | July 21, 1990 | Maize-Imp/Breeding |
| 30.Adikari, Bishwa Bhakta | February 16, 1991 | July 27, 1991 | Maize-Imp/Breeding |
| 31.Shah, Surya Narayan | February 16, 1991 | July 27, 1991 | Maize-Prod/Aron/CMR |
| 32.Mandal, Dayanand | February 12, 1994 | July 16, 1994 | Maize-Imp/Breeding |
| 33.Chaudhary, Devendra Kumar | February 20, 1995 | August 19, 1995 | Wheat-Imp/Pathology |
| 34.Ghimire, Surya Prasad | July 1, 1995 | November 1, 1995 | Maize-Prod/Aron/CMR |
| 35.Shrestha, Keshav Lal | July 1, 1995 | November 30,1995 | Maize-Prod/Aron/CMR |
| 36.Regmi, Babu Ram | April 1, 1996 | August 31, 1996 | Maize-Prod/Aron/CMR |
| 36.Chaudhary, Bharat Prasad | April 1, 1996 | August 31, 1996 | Maize-Prod/Aron/CMR |
| 37.Neupane, Devidas | April 1, 1995 | August 31, 1996 | Maize-Prod/Aron/CMR |
| 38.Vishwakarma, Shiv Shankar | June 1, 1997 | October 31, 1997 | Maize-Prod/Aron/CMR |
| 39.Kunwar, Chitra Bahadur | February 14, 1998 | June 9, 1998 | Maize-Imp/Breeding |
| 40.Chhetri, Jhalak Bahadur | April 1, 1998 | August 31, 1998 | Maize-Prod/Aron/CMR |
| 41.Rijal, Tirth Raj | July 19, 1999 | November 11,1999 | Maize-Imp/Breeding |
| 42.Joshi, Kiran | February 14, 2000 | August 11, 2000 | Maize-Prod/Aron/CMR |
| 43.Katuwal, Ram Bahadur | February 14, 2000 | August 11,2000 | Maize-Prod/Aron/CMR |

## Annex 3.

### Participation of Senior Maize Researcher as a Visiting Scientists on CIMMYT Maize Program

| Name | From | To |
|---|---|---|
| 1. Lal, Kaushal Kishor | July 17, 1984 | August 3, 1984 |
| 2. Basnyat, N.B. | September 16, 1974 | December 21, 1974 |
| 3. Nepali, S.B. | September 21, 1976 | September 28,1976 |
| 4. Rajbhandary, Gopal | September 15,1979 | September 29,1979 |
| 5. Mishra, Toya Nath | July 31, 1980 | |
| 6. Sharma, Prasad Vishnu | July 31, 1980 | |
| 7. Lal, Kaushal Kishor | August 31, 1980 | September 5,1980 |
| 8. Manandhar, K. L. | January 18, 1982 | March 18, 1982 |
| 9. Bhimsen, K.C. | January 18, 1982 | March 18, 1982 |
| 10. Shivakoti, Gopal Prasad | January 20, 1982 | February 20, 1982 |
| 11.Gupta, Uma | January 24, 1982 | February 6, 1982 |
| 12. Sherchand, Kishor | March 3, 1982 | March 18, 1982 |
| 13. Adhikari, Krishna | September 1, 1990 | November 5,1990 |
| 14. Kiorala, Keshab Babu | August 5, 1997 | November 15,1997 |
| 15. Adhikari, Krishna | August 14,2000 | September 13,2000 |

“सुवीजम् सुक्षेत्रे जायते सम्पधते” - ऋग्वेद

*“Good seed in good land yield abundant” - RIGBEDA*

# Three Decades of NARC-CIMMYT Partnership in Wheat Research and Development

T. P. Pokharel, National Wheat Coordinator
M. R. Bhatta, Wheat Breeder

*National Wheat Research Program, Bhairahawa*

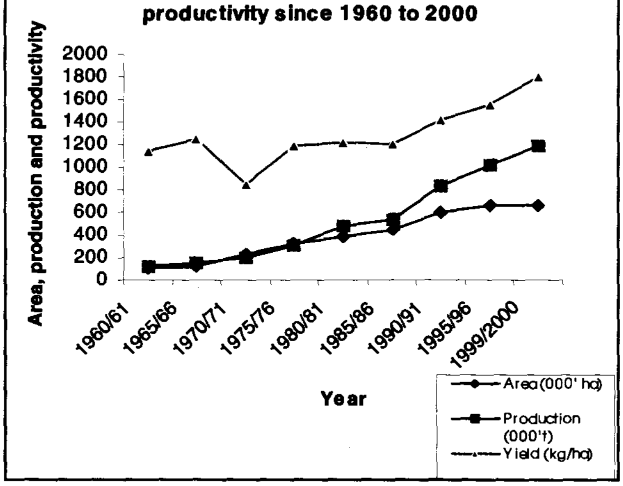
## Introduction

Wheat is the third important APP (Agriculture Perspective Plan) prioritized cereal crop after rice and maize in Nepal. It is grown in Terai, river basins, mid-hills and high hills of Nepal in winter. Summer planting in high hills of Nepal is not uncommon. Unlike rice in summer, wheat is not a sole crop in winter. Winter legumes (Lentil, Chickpea, Lathyrus, Peas), oil crops, potato and a number of winter vegetables are alternative to wheat. Farmers may prefer not to grow wheat in large areas if they harvest bumper rice crop. A poor rice crop prompts them to grow more wheat for their food security. Higher prices of grain legumes and oil crops entice farmers to grow them instead of wheat. High price of chemical fertilizers further discourages wheat growers as wheat is grown only with added fertilizer. In spite of these constraints, wheat production and productivity are increasing because of appropriate wheat technology developed by NARC scientists as we will see in the following highlights.

In a span of 35 years (1965-2000) Nepal has made a spectacular progress in wheat production. The area under wheat increased by more than 6 fold, the production by 10 fold, and the productivity by twofold (Figure 1) in this period. There are four main reasons for this:

1. Nepal is suitably placed for wheat cultivation as it is above the tropic of cancer. The soil is neither too acidic nor too alkaline. The climate on the whole is favorable.

**Fig.1. Trend in wheat area, production and productivity since 1960 to 2000**



2. High yielding varieties of wheat having wide adaptation started replacing the local land races
3. Improvement in overall wheat crop management.
4. CIMMYT's support in providing germplasm, training and higher studies.

The wheat production requirement by the year 2020 is 16,34,000 metric tons, if the population increases exponentially. It is projected to 14,79,000 metric tons in case the population increases linearly and 12,39,000 metric tons if it increases in a sigmoidal fashion. The production figure achieved for FY 1999/2000 is 11,83,530 metric tons a preliminary estimate (CBS, 2000). It appears that we are close to the target in 2000 itself. However, we should not feel satisfied at this level. The APP envisages a growth rate of 5% per annum in agriculture from the present growth rate of about 3% per annum. It is an uphill task. It is the appropriate technology that counts after all. The researchers at National Wheat Research Program (NWRP), NARC will try their best to develop technology that reduces production cost, and enhance productivity of wheat. As the cost of production goes down, consumers get cheaper wheat products.

Wheat generally matures in 140-150 days in Indian Punjab whereas it matures in 130 + days in mid and far-western Terai of Nepal. It comes to maturity in 115 + days in eastern, central and western Terai. It is almost a 6-month and 7-month crop in Kathmandu and Jumla valley respectively due to higher elevation. It is clear from these citations that higher latitude and elevation favor wheat crop. Apart from higher latitudes and elevations, it is important to note that wheat grows best on well-drained soils. It partly explains why grain yields are high in Bara and Parsa district.

If one manages wheat crop, one can easily get 3.5 t/ha to 4.5 t/ha in eastern, central, western Terai, 4.5 to 5 t/ha in mid and far western Terai with the present wheat production technology that NWRP has developed. Strategic research is required to know which Terai regions are more productive than others so as to prioritize area and concentrate wheat production at lower cost of cultivation. The river basins are favorable and so do the mid-hills.

## Summary

We know that wheat varieties that triggered Green Revolution in India/Pakistan were developed at CIMMYT, Mexico. These varieties had wide adaptation, were resistant to all prevalent diseases and were responsive to higher fertilizer use along with 3 to 4 irrigations in their growth period. Above all, they were high yielding and fit well in the cropping pattern especially in Rice-Wheat System. Up to mid-1960's long-duration and photosensitive rice varieties prevented wheat from sowing the then local wheat varieties that required to be planted in last week of October to first week of November. RR21, the first generation high yielding wheat variety could be planted in the whole month of December to first week of January in Terai and was far superior to the existing local varieties in yield. It was high yielding in 1970's, had attractive bold grain which shriveled proportionally less in delayed sowing as compared to other varieties. It was the variety in Rice-Wheat System in late-sown conditions. It used to be widely planted in Terai, mid-hills and even in high-hills in Nepal. It is still grown in hill niches and some parts of Terai. U.P. 262 and Nepal 297 are other popular varieties of wheat, the first in 1980s up to mid 1990s and the later in mid 1990s. Bhrikuti is another highest yielding variety that is becoming popular in Terai.

In wheat crop management, National Wheat Research Program has identified several technologies which need popularization for increased yields. We know the optimum time of planting wheat in Terai, mid-hills, high-hills and interaction of varieties (timely, late sowing) with planting dates. The input requirements for maximum yields are established. The biotic and abiotic constraints to yields are identified. Surface seeding technology is useful when one is confronted with excess moisture at the wheat sowing time. Wheat can be successfully relayed in rice without adverse effect in yield. Chinese hand tractors can be efficiently used in wheat planting without further delay. Zero-till drill requires no land preparation and one can drill seed with fertilizer with savings in fuel, and irrigation water. The bed planting of wheat appears to be highly promising.

Since the establishment of National Wheat Commodity Program in 1972, wheat germplasm flow is continuous from CIMMYT, Mexico. Many scientists have been given short-term (3-6 months) training in several components of wheat (breeding, pathology, agronomy, quality) at CIMMYT Headquarters in Mexico

(Appendix 3). Some of them have got academic training with CIMMYT's support. They have regularly attended the Indian wheat workshop that is held annually in India. The logistic support to international visits and seminars for our scientists in third countries has come from CIMMYT Regional South Asia Office in Kathmandu. Wheat coordinators and senior breeders have been to CIMMYT research center in Mexico as visiting scientist to acquaint themselves with the research work including its management on the whole (Appendix 4). Our wheat scientists are thus more or less exposed to the present advances in wheat research worldwide. They are often in the right tract and are doing a fine job on the whole.

## Wheat Research and Development

The history of introduction of semidwarf Mexican wheat varieties began in late 1960s in Nepal. Prior to the introduction of Lerma Rojo 64, Sonora 64, Pitic 62 and Kalyansona, Lerma 52 from Mexico had gained popularity in mid-hills. It was soon replaced by Lerma Rojo 64, short stature, non-lodging and high yielding wheat variety. Sonora 64 and Pitic 62 were not accepted by farmers on grounds of shriveled grain and late maturing behavior. Lerma Rojo 64 became popular in Kathmandu valley. Kalyansona (S227), a Mexican line selected in India, had to be withdrawn after 3 years of recommendation as it became susceptible to leaf rust epidemic in 1971/72. RR21 (Sonalika), a CIMMYT line released in 1971 proved to be a miracle wheat variety which even spilled over to high-hills, what to talk of Terai and mid-hills. The popularity of the variety can be sensed as it occupied 70% of wheat area in 1970s. It is estimated that it still covers 10% of the wheat area. In keeping with the objectives of Ten-year Agriculture Development Plan that envisaged the establishment of five commodities namely rice, maize, wheat, potato and sugarcane, National Wheat Development Program (NWDP) was established at Division of Botany, Khumaltar in 1972 and later moved down to the present headquarters, Bhairahawa (about 282 km southwest of Kathmandu) in 1974. In 1990 NWDP was separated from Department of Agriculture and under new structure remained under the Nepal Agricultural Research Council (NARC) with its present name of National Wheat Research Program (NWRP).

## Highlights on NARC-CIMMYT Collaboration

**(A) Wheat Breeding and Wheat Varietal Development**

The priority in NWDP in 1970s was varietal development. NWDP was flooded with wheat genetic materials from CIMMYT (F2 segregating materials, international nurseries, elite wheat yield trials, international spring wheat field nursery etc.), from India (Uniform regional yield trials which are called Advanced Varietal Trials now) and from ICARDA, Syria (Nurseries and yield trials). Our breeders were highly enthusiastic to start selecting right from F2 in the one hand and identify suitable varieties from yield trials for Terai, mid-hills and high-hills on the other hand. The release of HD1982 (an Indian variety) and NL30 (a CIMMYT line) in 1975 for Terai was initially greeted with cheer. However, HD1982 was not accepted by farmers as sterility in farmers' managed parcel was associated with it. NL30 was liked to some extent by the farmers of mid-hill and far-western foot-hills.

The establishment of Integrated Cereal Project in 1977 was a landmark in the commodity program. It gave a wake-up call through belated, to all researchers to think of the farmers' conditions under which a crop is grown before a technology is given a green signal. The feedback from the cropping system site was unprecedented. Many researchers got the opportunity of higher training and after their completion initiated research on farmer's problems on cropping systems perspective.

Meanwhile, the release of UP262 in 1978 for Terai greatly enhanced the credibility of the disciplinary divisions and wheat commodity program as a whole because of its wide acceptance by farmers of Terai.

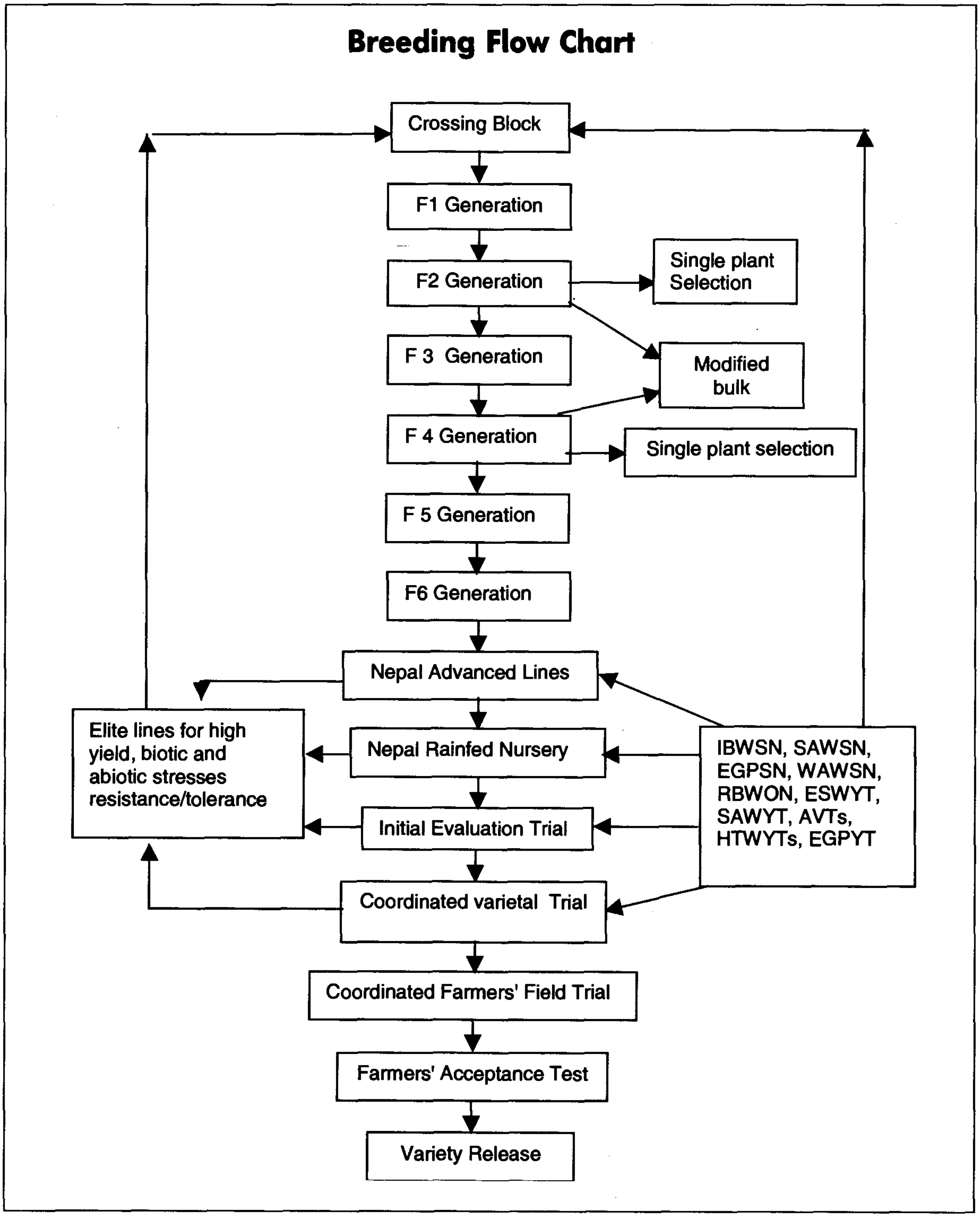
The South Asia Regional Office of CIMMYT came into being in 1985 and helped establish a close link with our institution. An MoU was signed to facilitate research work between our institution and CIMMYT.

In 1980s, NWDP had competent wheat researchers/breeders and a sound breeding program was established with help from CIMMYT regional office. A shaky wheat breeding program of 1970s has been transformed into a stable dynamic program since 1980 with several twists and turns.

The history of wheat varietal development and the future candidates for release are depicted in "Wheat

Varietal Display" which indirectly gives the visitors the genetic gains in yield of every decade beginning 1960. The crossing block consisting of spring wheat varieties, worldwide and indigenous, is composed of. Breeders has full knowledge of the characters to be converged into a single genotype.

The hybridization program was efficiently carried out by breeders and a number of support staffs. The growing of F1 to F6 generation lines became a part and parcel of the breeding program despite objections by a few on the questions of sustaining the program. A shuttle breeding program was initiated first at Nigale potato farm, Sindhupalchowk District and now at Marpha Horticulture Farm, Mustang where the segregating materials were grown in summer. We could thus get two generations a year instead of a single generation which in turn cut short varietal identification process by 3 to four years. It was exciting and is still exciting. The support from CIMMYT trained wheat pathologists was excellent. The collection of rust spores from different parts of the country was done with logistic support from CIMMYT



and inoculation was accomplished as and when needed. Meanwhile, Lumbini, Triveni, Vinayak, Siddhartha, (all Indian lines of CIMMYT blood) and Vaskar (a CIMMYT line) were released for Terai in the first part of 1980s. They could not compete with UP262 and RR21, though Triveni, Vinayak and Siddhartha are still grown in limited scale in western and far-western Terai. Nepal 297, (an Indian variety) which was not released in India comparable to RR21 in maturity and 1000 grain weight with high yield potential was released in 1985. It also had foliar blight tolerance as well as sterility resistance. It has replaced RR21 and UP262 in Terai and is now the number one variety in the country. It has also done well in the hills.



Annapurna 1 and Annapurna 3 considered Universal variety in the name of Veery by CIMMYT were released in 1988 and 1991 respectively for mid-hills such as Kathmandu valley with the active role of the breeders of the Division of Botany, Khumaltar.

BL1022 (BL stands for Bhairahawa line) was the first variety developed by NWRP and released in 1991 for western, mid-western Terai. It has wide acceptance in the area. In 1994, BL1135, Bhrikuti and Annapurna 4 were recommended for general cultivation for farmers. BL1135 like BL1022 were developed by NWRP from F2 segregating materials from CIMMYT. It is preferred in mid and far western Terai regions. Bhrikuti (a CIMMYT line) has the highest yield potential ever identified and released for Terai. Annapurna 4 (a CIMMYT line) is performing well in mid-hills as well as river valleys.

Rohini (a CIMMYT line) for Terai regions, Pasang Lhamu and Kanti (Both CIMMYT lines) for mid-hills and Achyut (an Indian line) for Terai were released for cultivation in 1997. BL1473, a variety bred and developed in Nepal, was released for the whole of Terai. Like Nepal 297, it is high yielding and is resistant to sterility.

**Eastern Gangetic Plains Research Partnership**

This EGPRP is a brainchild of Dr. G.O. Ferrara, Principal Scientist/Regional Coordinator, CIMMYT South Asia Program.

**Introduction**

CIMMYT-South Asia Wheat Regional Program, in close partnership with the National Wheat Research Program (NWRP) of the Nepal Agricultural Research Council (NARC), jointly coordinates a regional germplasm and research information Network titled Eastern Gangetic Plains (EGPs) Research Partnership. The main objectives of the EGP network are:

1. Identify and exchange superior wheat germplasm and breeding methodologies through a collaborative network
2. Identify wheat varieties adapted to the Rice-Wheat cropping systems in the Eastern Subcontinent
3. Promote the release and adoption of improved wheat varieties
4. Enhance the research capabilities of participating NARS

The purpose of the EGPs Network is to assemble elite wheat lines provided by (National Agricultural Research System (NARS) breeders working in Eastern and Far Eastern India, Bangladesh and the Terai of Nepal, and to distribute and test them regionally in the EGPs. The main goal is to identify, select, and share improved wheat germplasm regionally, with combined resistance/tolerance to Helminthosporium leaf blight, leaf rust, heat, with appropriate maturity, white bold seed, and with high yield potential/ adaptation. The germplasm is distributed to cooperators in the form of an Eastern Gangetic Plains Screening Nursery (EGPSN) and/or an Eastern Gangetic Plains Yield Trial (EGPYT).

**Highlights**

The EGPSN and EGPYT have been successfully distributed for the last four wheat seasons from Nepal to cooperators in the EGPs. Collaborators have praised the leading role of NARC-Nepal in distributing these nurseries. More than 600 genetic stock with resistance to the biotic and abiotic stresses common in the EGPs have been distributed and selected from these two nurseries. Breeders from Eastern India, Terai of Nepal and from Bangladesh have been requesting more and more sets of these nurseries and they have reported and praised the good adaptation and the value of the germplasm in their breeding programs.

Fifteen sets of the 4th Eastern Gangetic Plains Screening Nursery (4th EGPSN) and twelve sets of the 2nd Eastern Gangetic Plains Yield Trial (2nd EGPYT) were distributed in September 2000. Summary reports of previous EGPSNs and EGPYTs have been sent annually to collaborators in electronic form, allowing them to use that information in their own breeding programs. Top HLB resistant lines and highest yielding lines are presented in table 1 and table 2 respectively.

**Table 1. Top HLB Resistant Lines, 3rd EGPSN 1999-00**

| Cross and Pedigree: | HLB Score (3rd Reading) | Average Grain Yield (Kg/ha) |
|---|---|---|
| Milan/Sha7<br>CM97550-0M-2Y-030H-3Y-1Y-0Y-1M-010MY-0M | 47 | 4690 |
| Milan/Sha7<br>CM87550-0M-2Y-030H-3Y-3Y-0Y-1M-010Y-0FUS-3FUS-015PR-0B | 52 | 5000 |
| Chirya-7<br>CIGM87.1017-6Y-2M-3PR-1M-3PR-3B-0PR | 55 | 3990 |
| Klat/Soren//Psn/3/Bow/4/Vee#5.10/5/....<br>NC2142-16B-020B-025B-4B-0B | 60 | 4400 |
| Local Check (Improved) | 75 | 4240 |
| HLB Resistant Check (Chirya-3) | 61 | 3550 |
| HLB Susceptible Check (Sonalika) | 81 | 3690 |

**Table 2. Highest Yielding Lines, 1st EGPYT 1999-00**

| Cross and Pedigree: | Grain Yield (Kg/ha) | %> Bhri | %> Ska |
|---|---|---|---|
| BL-1804 (=Attila//Jup/Bjy/3/Attila)<br>CMBW89Y00402-0TOPM-2B-020B-020B-1B-0B | 4510 | 109 | 133 |
| BL-1968 (=NL-297*2/Danial 88//HLB 18)<br>NC 2025-2B-020B-010N-1B-0B | 4360 | 105 | 128 |
| NL-750 (=CS/A.Curv//Glen/3/Ald/Pvn...)<br>CIGM87.116-3Y-1M-4PR-1M-2PR-2B-0PR | 4358 | 105 | 128 |
| PBW-343 (India) | 3936 | 95 | 116 |
| Bhrikuti (Nepal) | 4151 | 100 | 122 |
| Sonalika (Long Term Check) | 3403 | 82 | 100 |
| Kanchan (Bangladesh) | 3723 | 90 | 109 |

During the 1999-2000 wheat season, one hundred and fifty new crosses with targeted parents from the region and from CIMMYT-Mexico were made by the NWRP of NARC in Bhairahawa, Nepal. Several outstanding crosses made during the last three years, with combined resistance to HLB, leaf rust, heat tolerance, bold white grain etc., are now in the F5 stage of the breeding program. Some of these crosses would be included in the 5th EGPSN during the 2001-2002 wheat season. Plans are under way to start conducting Participatory Varietal Selection (PVS) activities with the top performing lines of the EGPYTs.

Good linkages have been established with the CIMMYT-based bread wheat breeding program. Elite selections made by the South Asia wheat breeders during their yearly visits to Mexico have been retested in the Terai of Nepal and incorporated in the EGPSN. These selections involve targeted crosses with elite parents from the region and from CIMMYT-Mexico.

A National Traveling Wheat Seminar was organized in Bangladesh with breeders and pathologists of the EGPs. Collaborative breeders and pathologists in this network have exchanged visits to familiarize themselves with the wheat research in other participating countries.

We have more than 20 new lines viz., BL 1724, BL 1755, BL 1813, BL 1862, BL 1868, BL 1872, BL 1887, BL 1905, BL 1923, BL 1938, BL 1965, BL 1968, BL 1981, BL 2015, BL 2049, BL 2069, BL 2075, BL 2182, BL 2207, and BL 2218 bred in Nepal currently under evaluation in national yield trails. Similarly, many varieties of CIMMYT origin are in pipeline.

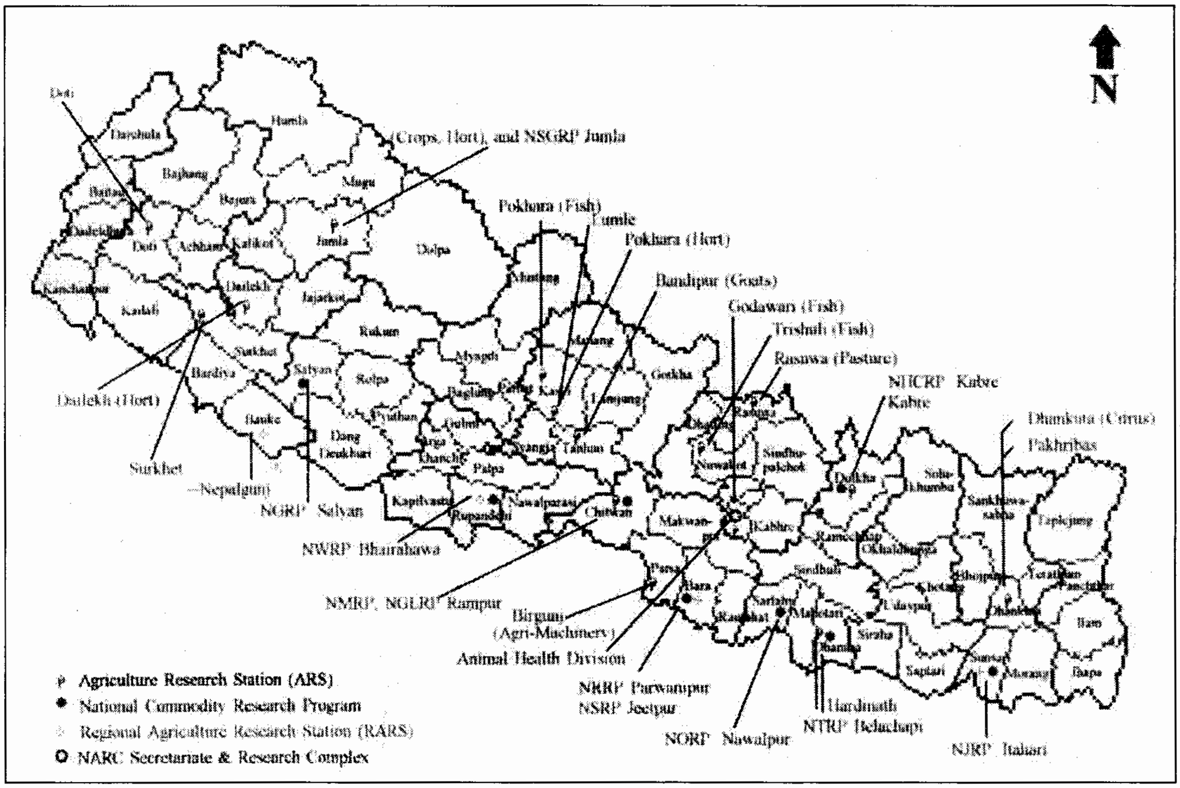
So far we have recommended 27 wheat varieties in 40 years beginning 1960. Thirteen (13) varieties are in the process of denotification and 14 varieties are being cultivated by farmers (Appendix 1 and 2).

We have thus gained spectacular success in varietal development from joint effort and collaboration with global partners like CIMMYT, ICARDA and Indian Wheat Program.

In Nepal, wheat research is carried out at mainly six locations in Terai, namely Tarahara (RARS, Eastern Terai), Parwanipur (RARS, Central Terai), Rampur (Inner Terai), Bhairahwa (NWRP/RARS, Western Terai) and Nepalgunj (RARS, Mid and Far western Terai). Similarly, Pakhribas (eastern hills), Khumaltar (central hills), Lumle (western hills), and Dailekh (mid western, mid-hills) research station carry out wheat research work in coordination with NWRP, Bhairahawa. Khumatar complex which also houses Nepal Agriculture Research Council has all crop disciplinary divisions such as Entomology, Plant Pathology, Soil Science, Botany (Mother Division of breeders), Engineering and Agronomy. A modest wheat breeding program is carried out by Botany Division in full coordination with NWRP, Bhairahawa. The role of the Botany Division is indispensable for wheat varietal development for mid-hills and high-hills. The roles of other Divisions are equally important for wheat commodity.

Jumla, Agricultural Research Station ( ARS) represents high hills environment. ARSs, Doti and Surkhet are other sites for river valley situations. Marpha Horticulture Farm is utilized for summer wheat plantains under shuttle breeding program. One can utilize on request other several Government farms/ stations spread across the country for research purpose.

NWRP is required to provide wheat genetic materials to test at the above mentioned RARS/farm stations. Upon request it meets the requirements of even segregating materials of any of the research farms/stations/RARS if they have manpower to execute and promote them further. Generally, it provides



Advance Lines (usually 350 lines), Initial Evaluation Trial (rainfed/irrigated generally consisting of 25-36 new varieties), Coordinated Varietal Trial (rainfed/irrigated/late sown, usually consisting of 16-20 new varieties), Nepal Disease Screening Nursery (more than 300 lines/varieties from advanced lines, initial evaluation trial, coordinated varietal trial etc.) and Component Technology Trial, popularly called as coordinated farmer's field trial (5 to 6 varieties) to the above mentioned RARS/ARS/Stations. NWRP has to provide the required amount of breeder seed of the wheat varieties to these research institutes. It is important to note that all these RARS, ARS and farms have the mandate to conduct outreach research at their command area. Sound performance of new varieties in farmers' field is required for the recommendation of the variety for general cultivation. The varietal component technology trial is research managed whereas the minikits by the name of FAT (Farmers' acceptance test) is extension managed. The feed back from these nation wide trials is very important in varietal release. For the last 2 years, participatory varietal selection (PVS) has been initiated in Terai plus hills and the results are encouraging. Because of these several research networking and genuine desire on the part of the collaborators (senior level scientists) to promote wheat research, National Wheat Research Program is successful in identifying high yielding second generation modern wheat varieties for farmers' of a country as highly diverse as ours.

### (B) Wheat Pathology

Pathologists and breeders have always worked together in wheat breeding and varietal development since the establishment of National Wheat Development Program in 1972. The outcome is productive with so many commercial varieties possessing durable resistance to leaf rust which is one of the major hazards to wheat production. The appearance of new races of leaf rust in 1970s namely 77-2, 77-4, 77-5, and 104-3 was less threatening to wheat as its production has increased on the whole.

In Rice-Wheat systems, foliar blight complex caused by *Bipolaris sorokiniana and Pyrenophora tritici-repentis* is now regarded as the number one wheat disease especially in Terai where poor drainage greatly favors its development. One of the major challenges to wheat pathologist right now is this disease that greatly reduce wheat yield. Nepal 297 has tolerance to this disease and many of its progenies appear outstanding. The yield loss estimates at NWRP, Bhairahawa is around 24%. Majority of the varieties are susceptible, however, lines derived from *Thynopyron curvifolium,* hexaploid synthetics derived from Tetraploid and *Triticum tauschii* and some Chinese varieties have shown adequate levels of resistance. Propiconaole (Tilt 250 EC) sprays helps minimize the loss. Solarization also helps minimize the loss due to foliar blight. Two irrigations appear to give better control (Mahto, 1995).

Since 1999, The Helminthosporium monitoring nursery (HMN) is organized and distributed from Nepal. This joint effort between Nepal and CIMMYT is complimentary to regional breeding initiatives in the Eastern Gangetic Plains (EGPSN and EGPYT). The objectives are: detecting possible genotypes environments/pathogen interactions, proposing new promising genotypes selected in the region (white bold grain), monitoring possible changes in virulence, to exchange germplasm and information, and to assess potential yield losses. The materials include sources of resistance from China, Zambia, South Asia and wide crosses and systhetics.

Support was given to NWRP conducting trials on the effect of reduced or imbalanced soil fertility on foliar blight progress. Potash (K) has been identified as a key limiting factor in long -term trials in Bhairahawa and its deficiency influences the severity of foliar blights. CIMMYT supported the laboratory analysis in Belgium of mineral contents in leaf samples and data analysis of trials conducted by NWRP. Results show highly significant differences between treatments regarding total ashes, P, Na and Ca level and significant differences according to K level.

Stripe rust *Puccinia striiformis* initially attacks wheat in mountains, mid-hills, and foot-hills but it quickly disappears when the temperature starts rising. RR21 in mid 1980s became susceptible to stripe rust in central and eastern Nepal due to the appearance of new virulent race 7E150 (Sharma et al).

The migration of the Yr9 attacking pathotypes from the middle-east to the subcontinent and consequently to Nepal has been confirmed as Annapurna 1 and Annapurna 3, all Veery derivatives associated with 1B/1R translocations have been for the first time infected by stripe rust (46S119). It has alerted us to identify the varieties having Yr18/Lr34 genes and go for synthetics.

Nepal participates to the regional disease trap nursery also known as SAARC nursery organized by

DWR, Shimla-India. This nursery is sown at 5 locations and is a 'South Asian Association for Regional Cooperation' (SAARC) effort to monitor rust epidemics in the region. CIMMYT supports this initiative, helps with data collection, return and flow of information.

As part of the global effort to monitor virulence changes in rusts under the leadership of CIMMYT headquarters, seed of differential lines for the International Disease Trap Nursery (IDTN) were prepared in Nepal. Regional monitoring has been initiated at a total of 17 sites in Pakistan, India, Nepal and Bangladesh. CIMMYT also provided to NARC differential lines and other useful materials from Central Asia, Pakistan and Mexico to assess rust epidemics.

Loose smut *Ustilago tritici* and common bunt *Tilletia tritici* and I. Laevis are the major concerns in the hills. The losses are minimized by the use of resistant varieties coupled with seed treatment especially with Vitavax 200. Other chemicals for seed treatment are Bavistins and Raxil. Annapurna 4 and BL1135 appear immune to loose smut under field conditions (Karki).

Powdery mildew *Erysiphe graminis* f.sp.tritici attacks wheat in western, mid- and far- western Terai, however, it does not appear damaging. *Fusarium graminearum, Bipolaris sorokiniana* and *Meloidogyne graminicola* are reported as potential root pathogens of wheat in Rice-Wheat system.

### (C) Soil Health Research

In March 2000, two scientists from Nepal (NARC) participated to the hands-on training organized by CIMMYT and CABI Bioscience on soil and root microorganism identification in Pakistan (Islamabad).

On January 17-18, 2001 a technical project workshop on 'Soil Health in Rice-Wheat Systems Considering Changing Tillage Practices' was jointly organised by CIMMYT, CABI Bioscience and Cornell University. This meeting hosted in Kathmandu allowed 8 Nepali scientists from Nepal Agricultural Research Council (NARC) and Institute of Agriculture and Animal Science (IAAS), Rampur to interact with colleagues from Bangladesh, India and Pakistan. The objectives were :

To discuss ongoing soil-health research activities undertaken through three special projects:

- DFID CRF (R7263) (C): "Soil-Health and Sustainability of Rice-Wheat Systems of the Indo-Gangetic .Plains" .
- DFID CRF Project (R7259) (C): "Harnessing Tillage by Nutrient Management Interactions using Participatory Approaches to Improve Rice-wheat Systems Productivity and Sustainability".
- CRSP: "Sustainability of Post-Green Revolution Agriculture: The Rice-Wheat Cropping System of South Asia"
- To get an interaction between project members so all know what each is doing.
- To document soil health constraints in Rice-Wheat systems and to see if tillage affect soil health significantly.
- To develop synergies between projects and increase research efficiency.
- To agree on protocols and reassess future needs.

In 1999 and 2000, CIMMYT provided logistical support to NARC scientists in implementing ongoing collaborative research on soil health including sampling in farmers' fields in Sipaghat and Bhairahawa areas.

The Division of Plant Pathology, Khumaltar also carries out routine surveys and surveillance work in collaboration with CIMMYT and NWRP. It fairly gives us an idea of the prevailing wheat disease situation across the country. CIMMYT's roles in strengthening pathology laboratory at NWRP headquarters, creating facilities for artificial inoculation of leaf rust and training of plant pathologists at CIMMYT headquarters have greatly consolidated wheat pathology research in the country .

### (D) Agronomy and Soils Research

Agronomy research on wheat was confined to seeding dates, seed rates, seeding methods (line sowing vs broadcasting), weed control (weedicide vs hand weeding) and fertilizer trial (variety cum fertilize trial) etc. The optimum dates for wheat plantings (Nov 15 for Terai and Oct. 15 for mid-hills) were established. The interactions between varieties and seeding dates were significant. It led to the recommendation of varieties for timely and late sown conditions. Similarly, seed rates for timely and later sown conditions differed significantly. 2,4-D was recommended for broad leaved weed control and Isoproturan for narrow leaves particularly for *Phalaris minor*. The need of balanced dose of NPK for sustaining wheat yields was realized in Rice-Wheat system.

Wheat agronomy and soil research received a face-lift with the advent of Dr. Peter Hobbs in CIMMYT Regional office Kathmandu in 1988. The sprinkler irrigation introduced by him at NWRP farm at Bhairahawa helped increase breeder seed production as the usual practices of first flood irrigation had damaging effect due to heavy soil on 21-25 day old wheat plants. The establishment of Rice-Wheat Consortium in which Nepal is a member in addition to India, Pakistan and Bangladesh in early 1990s identified the researchable areas in Rice-Wheat system which covers 12 million hectares in Indo-Gangetic Plains. Within its first year the consortium had developed outlines of a strategic plan covering four research themes:

- Soil fertility
- Water management
- Integrated pest management (IPM) and
- Crop establishment and tillage

Embedded in each of these themes are the issue of variety and social science. For example, developing varieties for reduced tillage systems.

## Achievements

A diagnostic survey was conducted in the rice and wheat seasons in 1989-90 which identified several factor constraining production of rice and wheat in Rupandehi districts.

One hundred seventy (170) farmer fields have been selected for monitoring over time. The benchmark was done in the first year. A multidisciplinary team has been monitoring every wheat and rice season to obtain data on trends since 1990. The number of farmers was reduced to 90 in 1995 for convenience. In 1995, soil analysis revealed depletion of most major and minor elements over time. Yields of both rice and wheat improved when additional inputs were applied (Giri).

To overcome the late sowing problems associated with wheat Chinese Hand Tractors (CHTs) were popularized with CIMMYT's initiatives in Rupandehi district where NWRP headquarters lies. These CHT perform three operation at a time, namely land preparation, seed drilling and planking. The demand of the CHT on the part of farmers is high and its import is on the rise.

The experiments on wheat relaying in rice fields with optimum moisture prior to its harvest by 10-12 days have revealed the ways of cutting down the cost of production of land preparation. Wheat can be relayed in non-lodged rice fields without sacrificing grain yield. In case of excess moisture, surface seeding technology developed by NWRP agronomist has been successfully employed. The zero-till drill technology from India is being simultaneously tested on NWRP research farm and farmers' fields. It appears highly promising because of savings in fuel for land preparation and irrigation water in addition to lesser population of weeds especially that of *Phalaris minor* (where tillage is practiced, the seed of Phalaris minor go underneath and geminate along with wheat). The yellowing of wheat is unlikely when the first irrigation is given as water absorption is less and water stagnation is almost nil in the zero till-drill technology. The grain yields tend to be high as delay due to land preparation does not occur and the wheat crop does not suffer the first flood irrigation shock the yellowing syndrome.

The bed planting of wheat employing the bed planter is being researched by NWRP Agronomist and Breeders alike as inputs like seed requirement is 1/3 to 1/2 of normal practices. The intercultural operations are easy and the grain yields are higher by at least one ton /ha over the conventional one with the less input.

In Rice-Wheat tillage experiments, deep tillage had no significant effect on rice grain yields but produced significant effect on wheat grain yields. The 3-year average yields of rice + wheat was higher by 4.06% (8408 kg/ha) than normal tillage 8,036 kg/ha) (Tripathi).

Direct seeded rice (5209 kg/ha) is as good as transplanted rice (5062 kg/ha). However, the wheat grain yields are significantly higher following direct seeded rice. There is significant depression in wheat grain yields following transplanted rice. Farmers can adopt direct rice seeding practices without sacrificing rice grain yields and harvest significantly higher wheat grain yields (as high as 55%, Tripathi). Advantages of DSR (Direct seeded rice), outweigh the TPR (Transplanted rice) in terms of cost and drudgery of the labors.

The Cornell Research Support Project (CRSP) is playing an important role in Rice-Wheat agronomy and soil research. It came into being in 1997 in Nepal. It has been giving operational funds, logistics and academic training. The Rice-Wheat research systems at Naldung (mid-hill/river basins), Bhairahawa (Terai) and Parwanipur are well supported by CRSP.

In long-term experiments in Rice-Rice-Wheat systems at NWRP, Bhairahawa, CIMMYT Agronomist helped modify experiments making it more meaningful in the present context. The treatments were split into sub-treatments twice, one in 1991 and the other in 1995 without affecting the original in 1991 treatments. The results upto 1991 were interesting. The early rice grain yields dropped to zero in the 5$^{th}$ year whereas the normal rice grain yields dropped to zero in the 18$^{th}$ year in minus phosphorus treatment. The grain yields were restored after the application of Phosphorus. Yield reduction in minus K treatment was also observed in all the three crops. The response of nitrogen was not seen in the absence of Phosphorus and Potash. The yield declined in all the treatment including NPK and farm yard manure.

A "Long-term Soil Fertility Experiment on Rice-Wheat System at NWRP, Bhairahawa" was started in 1988 with the initiative of CIMMYT Regional Agronomist, Dr. Peter Hobbs to study the effect of mineral fertilizers and/or manure in soil fertility in Rice-Wheat Systems. The rice grain yields showed increasing trend upto 4$^{th}$ year and started showing rapid nose-diving in grain yields in subsequent years (between 5 to 10 years). It agrees with the findings of P. Tan et al (1995) who reported the most rapid decline of rice grain yield in the treatment of N without Phosphorus (Regmi, 1998). Nitrogen together with sesbania and nitrogen with farm yard manure were invariably superior to nitrogen alone in determining rice grain yields. Nitrogen and Phosphorus combine were inferior to Nitrogen Phosphorus Dhaincha as well as Nitrogen, Phosphorus, FYM combine over 10 years with respect to rice grain yields. Application of Potash in Nitrogen Phosphorus receiving treatments tended to increase rice grain yields. With wheat, yield decline was observed right from the beginning of experiments even in the presence of Phosphorus. The Nitrogen Phosphorus FYM treatment exhibited minimum yield loss whereas Nitrogen Phosphorus combine revealed maximum yield loss over 10 years period. There was no residual effect of *sesbania* in wheat. Significant increase in grain yield of wheat was found with the application of 50 kg K20/ha (Regmi, 1998).

Dr. N.E. Borlaug, the Nobel Peace Prize winner, visited Nepal twice—once in the mid 1970s and the other in the 1980s. Many wheat researchers were encouraged to see him face to face. We highlighted the collaborative wheat research activities between Nepal and CIMMYT in both visits. His emphasis on wheat crop management for increased yield is still fresh in our minds. We want to quote some of his inspiring ideas, that echo in our minds and hearts.

1. "The world peace will not be built on empty stomachs and human misery"
2. "If you desire peace cultivate justice, but at the same time, cultivate the fields to produce more bread; otherwise, there will be no peace"
3. "The only way for agriculture to keep pace with population and alleviate world hunger is to increase the intensity of production in those ecosystems that lend themselves to sustainable intensification while decreasing the intensity of production in more fragile ecosystem"
4. "Plants talk to men but only in whisper, their voices can be heard by those who remain close to them"
5. "Plants will talk to you if you listen, but they won't shout. You'll never hear them if you stay in air-conditioned office"

6. When asked how to develop successful varieties Dr. N. E. Borlaug use to respond "you go to the field, and go to the field, and go to the field, and go to the field, when the wheat plant starts to talk to you, then you know you have made it"

The visit by Dr. M.V. Rao, the then India wheat coordinator, in late 1970s to Nepal has helped promote understanding between Nepalese and Indian wheat scientists.

Michael L. Morris, H.J. Dubin and Thaneswar Pokharel published "Returns to wheat breeding research in Nepal" in Agricultural Economics (1994) 269-282. They showed the internal rate of return to wheat breeding in Nepal during the green revolution period (1960-1990) stands at 75 - 84%. It endorsed continued investment for wheat breeding research in Nepal.

The joint NARC-CIMMYT activities to be implemented during 2001-2004 were discussed in a research consultation meeting at the Narayani Hotel in Kathmandu during November 2000. After in-depth and elaborative discussions, six major areas of collaboration namely crop improvement, crop protection, natural resources and crop management, socio-economics, human resources and regional cooperation have been identified and included in the work plan for implementation.

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## Appendix 1.

**Improved bread wheat varieties released since 1960.**

| Variety | Pedigree | Origin | Year of release | Area of adaptation |
|---|---|---|---|---|
| Lerma-52 | Mentana/Kenya 324 | Mexico | 1960 | Hills |
| Lerma Rojo-64 | Y50/N10B//L52/3/2*LR | Mexico | 1967 | Hills |
| Sonora-64 | YT54/N10B//2*Y54 | Mexico | 1967 | Hills |
| Pitic-62 | YT54/N10B 126.16 | Mexico | 1967 | Hills |
| Kalyansona | Pj"S"/Gabo 55 | Mexico | 1968 | Plains |
| RR-21 | II54-388/AN/3/YT54/N10B//LR64 | Mexico | 1971 | Hills and Plains |
| S -331 | LR64"S"/HUMANTALA(R) | Mexico | 1971 | Hills and Plains |
| NL-30 | HD832-5-5-OY/BB | India | 1975 | Western Plains |
| HD 1982 | E5557/HD845 | India | 1975 | Western Plains |
| UP 262 | S 308/BAJIO 66 | India | 1978 | Plains |
| Lumbini | E4871/PJ62 | India | 1981 | Plains |
| Triveni | HD1963/HD1931 | India | 1982 | Plains |
| Vinayak | LC 55 | India | 1983 | Plains |
| Siddhartha | HD2092/HD1962// E4870 /3/K65 | India | 1983 | Plains |
| Vaskar | TZPP/PL//7C | Mexico | 1983 | Mid-western plains |
| Nepal 297 | HD2137/HD2186// HD 2160 | India | 1985 | Plains |
| Nepal 251 | WH147/HD2160// WH147 | India | 1988 | Plains |
| Annapurna 1 | KVZ/BUHO//KAL/BB | Mexico | 1988 | Hills |
| Annapurna 2 | NPO/TOB//8156/3/ KAL/BB | India | 1988 | Hills |
| BL 1022 | PVN/BUC | Nepal | 1991 | Western terai |
| Annapurna 3 | KVZ/BUHO//KAL/BB | Mexico | 1991 | Hills |
| Bhrikuti | CMT/COC75/3/PLO// FURY/ANA75 | Mexico | 1994 | Plains |
| BL 1135 | QTZ/TAN | Nepal | 1994 | Plains |
| Annapurna 4 | KVZ/3/CC/INIA//CNO/ ELGAU/SN64 | Mexico | 1994 | Hills |
| Achyut | CPAN168/HD2204 | India | 1997 | Plains |
| Rohini | PRL/TONI//CHIL | Nepal | 1997 | Plains |
| Pasang Lhamu | PGO/SERI | Mexico | 1997 | Hills |
| Kanti | LIRA/FUFAN17//VEE#5 | Mexico | 1997 | Hills |
| BL 1473 | Nepal 297/ NL 352 | Nepal | 1999 | Plains and hills |

## Appendix 2.



**Wheat varieties currently popular in the country**

| S. No. | Variety | Parentage | Year of release | Area of adaptation |
|---|---|---|---|---|
| 1 | RR21 | II54-388/AN/3/YT54/N10//LR64 | 1971 | Terai and hills |
| 2 | UP 262 | S308/BAJIO 66 | 1978 | Terai (TS/I) |
| 3 | Nepal 297 | HD 2137/HD2186//HD2160 | 1985 | Terai (LS/I) |
| 4 | Annapuma-1 | KVZ/BUHO/KAL/BB | 1988 | Hills (TS/I) |
| 5 | Annapuma-3 | do | 1991 | Hills (TS/I) |
| 6 | BL 1022 | PVN/BUC | 1991 | Terai (TS/I) |
| 7 | Bhrikuti | CMT/COC75/3/PLO//FURY /ANA | 1994 | Terai (TS/I,LS/I) |
| 8 | BL 1135 | QTZ/TAN | 1994 | Terai (TS/I) |
| 9 | Annapuma-4 | KVZ/3/CC/INIA/CNO/ELGAU/4/SN64 | 1994 | Hills (TS/I, TS/R) |
| 10 | Achyut | CPAN 168/HD 2204 (K 9006) | 1997 | Terai (TS/I) |
| 11 | Rohini | PRL/TONI//CHIL | 1997 | Terai (TS/I, TS/R) |
| 12 | Pasang Lhamu | PAPAGO/SERI | 1997 | Hills (TS/I, TS/R) |
| 13 | Kanti | LIRA/FUFAN 17//VEE#5 | 1997 | Hills (TS/R, TS/I) |
| 14 | BL 1473 | NEPAL 297/NL 352 | 1999 | Terai (TS/I) |

## Appendix 3.

**Nepalese officials trained in Wheat crop in CIMMYT since 1968 to 2000**

| S. No. | Name | Date | Program |
|---|---|---|---|
| 1 | Badri Nath Kayastha | 1968 | Wheat improvement/Patho |
| 2 | Raj Bahadur Shrestha | 1971 | Wheat production |
| 3 | Achyuta Nath Bhattarai | 1974 | Wheat improvement/Patho |
| 4 | Chandra Bahadur Karki | 1975 | Wheat improvement/Patho |
| 5 | Thaneshwar Prasad Pokhrel | 1975 | Wheat improvement/Patho |
| 6 | Deep Man Sakya | 1977 | Wheat improvement/Patho |
| 7 | Ekjong Budhathoki | 1977 | Wheat production |
| 8 | Shyam Krishna Joshi | 1977 | Wheat production |
| 9 | Parashuram Lal Karna | 1978 | Wheat improvement/Patho |
| 10 | Bishnu Bikram Silwal | 1978 | Wheat improvement/Patho |
| 11 | Laxmi Datta Pant | 1978 | Wheat production |
| 12 | Kamala Prasad Sukla | 1978 | Wheat production |
| 13 | Lakshmeshwar Shrivastav | 1979 | Wheat production |
| 14 | Prachanda Man Shrestha | 1980 | Wheat improvement/Patho |
| 15 | Ram Hari Lal Singh Dangol | 1980 | Wheat improvement/Patho |
| 16 | Niranjan Prasad Rajbhandari | 1980 | Wheat production |
| 17 | Gokarna Bahadur G.C. | 1981 | Wheat improvement/Patho |
| 18 | Ravindra Nath Devkota | 1981 | Wheat improvement/Patho |
| 19 | Hari Prasad Bimb | 1981 | Wheat improvement/Patho |
| 20 | Tek Bahadur Karki | 1982 | Wheat production |
| 21 | Khelai Prasad Yadav | 1984 | Wheat production |
| 22 | Ram Prasad Shrestha | 1984 | Wheat production |
| 23 | Krishna Raj Regmi | 1985 | Wheat improvement/Patho |
| 24 | Ram Chandra Mishra | 1985 | Wheat production |
| 25 | Krishna Bahadur Kadayat | 1985 | Wheat production |
| 26 | Ganesh Sah | 1986 | Wheat Experiment Management |
| 27 | Akbal Ahmad | 1986 | Wheat production |
| 28 | Krishna Kumar Shrestha | 1986 | Wheat improvement/Patho |
| 29 | Laxman Singh Karki | 1987 | Wheat improvement/Patho |
| 30 | Madan Raj Bhatta | 1987 | Wheat improvement/Patho |
| 31 | Babu Ram Thapa | 1988 | Wheat improvement/Patho |
| 32 | Ram Chaudhary | 1989 | Wheat improvement/Patho |
| 33 | Bhuwon Sthapit | 1989 | Wheat improvement/Patho |
| 34 | Anant Prasad Regmi | 1989 | Wheat Production |
| 35 | Ghan Shyam Giri | 1990 | Wheat Production |
| 36 | Anand Kumar Gautam | 1990 | Wheat improvement/Patho |
| 37 | Baidhya Nath Mahto | 1991 | Wheat improvement/Patho |
| 38 | Shankar Lal Chaudhary | 1991 | Wheat Production |
| 39 | Bindeshwar Sah | 1991 | Wheat Production |
| 40 | Daya Ram Pokharel | 1992 | Wheat improvement/Patho |
| 41 | Lila Ram Paudel | 1993 | Wheat improvement/Patho |
| 42 | Devendra Kumar Chaudhary | 1995 | Wheat improvement/Patho |
| 43 | Nutan Raj Gautam | 1997 | Wheat improvement/Patho |

## Appendix 4.



**Nepalese Wheat Visiting Scientists to CIMMYT since 1974 to 2000**

| S. No. | Name | Date | Program |
|---|---|---|---|
| 1 | Netra Bahadur Basnyat | 1974 | General |
| 2 | Achyuta Nath Bhattarai | 1977 | Wheat |
| 3 | Achyuta Nath Bhattari | 1978 | Wheat |
| 4 | Shiv Nath Lohani | 1978 | Wheat |
| 5 | Prakirti Shamsher Rana | 1981 | Wheat |
| 6 | Parasuram Lal Karna | 1984 | Wheat |
| 7 | Mishri Lal Sah | 1984 | Wheat |
| 8 | P.P. Gorkhali | 1984 | General |
| 9 | V.P. Sharma | 1984 | General |
| 10 | Puskal Prasad Regmi | 1987 | Wheat |
| 11 | Ashok Mudwari | 1987 | Wheat |
| 12 | Thaneshwar Prasad Pokhrel | 1988 | Wheat |
| 13 | Moin Shah | 1989 | General |
| 14 | Kishor Kumar | 1989 | Wheat |
| 15 | Hari Prasad Bimb | 1990 | Wheat |
| 16 | Ravindra Nath Devkota | 1990 | Wheat |
| 17 | Govinda Prasad Pandey | 1993 | Wheat |
| 18 | Ravindra Nath Devkota | 1995 | Wheat |
| 19 | Ghan Shyam Giri | 1995 | Wheat |
| 20 | Madan Raj Bhatta | 1996 | Wheat |
| 21 | Daya Ram Pokharel | 1998 | Wheat |
| 22 | Dhan Bahadur Gharti | 2000 | Wheat |

## Agriculture Botany Division

### Outstanding Achievements Highlights on Three Decades of NARC-CIMMYT Partnership in Wheat Research & Development

- Lerma 52, Lerma Rojo 64, Pitic 62 were being popularly grown in valley and similar hilly region of the country.
- The establishment of South Asia Regional Office, CIMMYT in Kathmandu led to further strengthening of collaboration in various aspects. Germplasm from Latin American highlands were introduced for testing and utilization. Hill wheat breeding strategies were developed.
- With CIMMYT's initiation a project on wild emmer derivatives "Improvement of Cultivated Wheat by Transfer of the High Protein and Resistance to Powdery Mildew and Yellow Rust from Wild Emmer Wheat" 1990-93 was launched with CPRO-DLO, The Netherlands. The project led to number of useful germplasm for breeding program.
- With joint collaboration Participatory Varietal Selection Program has been initiated in Kathmandu valley and other parts of the country.
- High Altitude Wheat research was explored with CIMMYT germplasm (1998).
- Technical generation, information and dissemination system strengthened.
- Hill wheat varieties originating from CIMMYT germplasm which were developed in close collaboration with NWRP are as follows:

| VARIETY | PARENTAGE | YEAR OF RELEASE |
|---|---|---|
| 1. Lerma 52 | MENTANA/KENYA324 | 1960 |
| 2. Lerma Rojo 64 | Y50/N10B//L52/3/2*LR | 1965 |
| 3. RR 21 | II54-388/AN/3/YT54/N10B//LR64 | 1968 |
| 4. ANNAPURNA-1 | KVZ/BUHO//KAL/BB=(VEE "S") | 1988 |
| 5. ANNAPURNA-2 | NPO/TOB "S"//B156/3/KAL/BB | 1988 |
| 6. ANNAPURNA-3 | KVZ/BUHO//KAL/BB=(VEE "S") | 1991 |
| 7. ANNAPURNA-4 | KVZ//3/CC/INIA//CNO/ELGAU//SN64 | 1994 |
| 8. PASANG LHAMU | PGO/SERI | 1997 |
| 9. KANTI | LIRA/FUFAN17//VEE "S" | 1997 |

## Soil Science Division

### Research Highlights on Wheat Soil Fertility in Nepal

The available soil analysis data suggest that the soils in Nepal are generally low to medium in total nitrogen and medium to high in available phosphorus and potassium content in soil. Under such condition supply of nitrogen (N), phosphorus (P), and potassium (K) through external sources leads to increase in crop yield. The plant nutrients supplying practices through compost alone has become inadequate for improving soil fertility and maintaining the yield level under increasing cropping intensity. The better yield would be obtained from recommended levels of N, P, and K in wheat.



- The yield trend of wheat was increased mainly by N, P, and K fertilization in long-term soil fertility experiment in Terai. In the long-run, crop yields can only be sustained, if N, P, and K supplies are adequately balanced to replenish the crop removal. Application of 30-ton /ha /year FYM also produced the yields equivalent to 300:100:90 kg $N:P_2O_5:K_2O$ /ha/year. Additionally, it improved the soil fertility.
- On the basis of many on-station and on-farm research trials, a general rate of 100-150 kg N, 40-60 kg P205, and 30-40 kg K20/ha was recommended for wheat cultivation under irrigated condition.
- Besides N, P, and K, Micronutrients are also increasingly found limiting the wheat yields.
- Micronutrient such as Boron was identified which causes the wheat sterility particularly in the central and eastern parts of the country.

## Entomology Division, Khumaltar

### Screening of Promising Wheat Genotypes Tolerant to *Sitophilus oryzae*

Wheat is the third most important staple food crop of Nepal. After harvest of wheat, farmers have to store it for domestic consumption and for seed purpose. There are many evidences that a number of insect-pests cause significant losses both on quality and quantity of wheat during storage. Among them, *sitophilus* sp. is considered the most important one. The estimated wheat grain loss (by weight) caused by weevil alone has been reported 13 to 26 % in western Nepal (Panthee, et.al., 1993) and up to 33% in eastern Nepal (Paneru, et.al., 1993). Though Sitophilus species behave differently on grains depending upon the hardness and softness of endosperm. Bergvinson and CIMMYT (1998) have found considerable genetic variability to weevil attack in maize. They have further reported that anti-feed factors have been involved in the mechanism of resistance in quality protein maize ((QPM).

Nutrient constituents in different genotypes play a significant role in the feeding behavior of insects. Weevil multiplication depends on many factors such as temperature, moisture content of grains, hardness and softness of grain endosperm, and quality of wheat. Thus, number of eggs laying, and their potentiality to develop into adults and time taken to complete its development period may differ on type of wheat genotypes.

Considering above, the relative tolerance of *S. oryzae* to nine genotypes of wheat viz., RR 21, WK 823, WK 831, NL 810, NL 769, NL 7341, WK 810, Annapurna-1 and BL 1473, were assessed on the basis of number of weevil progeny emerged and percent grains bored on 500 seeds and 120 g of wheat grains.

The result indicated that damage caused by *S. oryzae* was comparatively lower in the grains at 12% grain moisture content (GMC) than that of grains at 14 and 16%. The genotypes WK 810 was found to be comparatively less susceptible to *S. oryzae* as evident from least number of progeny emergence and lowest percentage of grains bored. None of the tested genotypes were tolerant to *S. oryzae* to a minimum acceptable level. But, GMC and genotypes were found to have direct relationship with tolerable and susceptibility.

## Agricultural Research Station, Lumle

Annapurna-1, Annapurna-3, Annapurna-4, Pasang Lhamu and Kanti have been recommended for general cultivation for mid-hills. However, RR 21 is predominant variety which fits well in the cropping system in ARS, Lumle RCA. Annapurna-4 is gaining popularity in mid-hills. Other than that, BL 1473 is also performing well from low-hill to mid hills environments.

Wheat genotypes identified for different farming systems in close collaboration with NWRP.

| Genotype | Environments | Grain yield (kg/ha) | Straw yield (kg/ha) | Plant height (cm) | Maturity (days) | Fertility % | Spikes/ sqm | 1000 Grain wt.(gm) |
|---|---|---|---|---|---|---|---|---|
| For release NL 816 | Mid-hills, R-W system | 2460 | 11690 | 87 | 184 | 67.53 | 327 | 49.7 |
| NL 792 | Low-hills, R-W-R system | 3990 | 4000 | 95 | 128 | 79.1 | 277 | 51.9 |
| BL 1813 | Mid-hills, R-W system | 3320 | 10890 | 88 | 184 | 84.62 | 319 | 55.1 |
| In Pipeline BL 1755 | Mid-hills, R-W system | 2500 | 5700 | 103 | 179 | 75.72 | 272 | 65.7 |
| BL 1724 | Low-hills,R-W-M system | 3710 | 4200 | 83 | 156 | 84.9 | 242 | 48.6 |
| NL 781 | Low-hills, R-W-R system | 2700 | 4100 | 83 | 127 | 75.9 | 272 | 47.6 |
| BL 1905 | Mid -hills | 3295 | 1426 | 98 | 182 | 74.5 | 393 | 56.98g |

## Regional Agriculture Research Station, Nepalgunj

**Wheat varietal improvement**

**Popular wheat varieties in the region:**
Nepal 297, BL 1022, Achyut, Rohini, and Bhrikuti.

**Promising lines identified:**
For rainfed condition: NL 731 and NL 792
For irrigated condition: NL 731 and NL 750

**Soil fertility:**

- In Rice-Wheat system, long-term fertility trial, application of Phosphorus and Potassium showed significant effect on wheat yield.
- Response of Phosphorus and Potassium was more in wheat than rice.
- In the effect of green manuring in rice-wheat system growing Dhaincha as green manure was found superior in terms of yield performance of the system.
- Wheat sterility is not a problem at RARS, Nepalgunj even without the application of Boron.

**Agronomy**:

- In agro-forestry system, grain yield of rice and wheat was adversely affected when annual crops were grown closer (6 meter to mature *sisso* tree).
- November 20 to December 5 was the optimum time of sowing wheat under Nepalgunj condition.
- The contribution of wheat as preceding crop with rice was low as compared to chickpea and lentil.

**Plant pathology:**

Several wheat genotypes have been selected for *Helminthosporium* and rust disease resistance or tolerance.