The Kaghan offseason plant breeding station, Pakistan. Here in the Himalaya Mountains, wheat trials are exposed to several rust diseases, especially stripe rust, which occurs naturally and abundantly in this region.

CIMMYT TODAY No. 11

OFFSEASON NURSERIES:

SPEEDING THE BREEDING

WHEAT TRITICALE BARLEY

SPEEDING THE BREEDING

INTRODUCTION

In a world of relentless population growth, shrinking arable land resources per capita and an ever present need for more and better food for the impoverished, there is a tremendous task and responsibility for scientists, educators, administrators and politicians to produce and promote the adoption of agricultural technologies which will benefit mankind.

The cereal crops have much to offer towards the provision of more and better foods for the developing countries. Asia, Africa and Latin America produce more than 40 per cent of the world's wheat, maize and barley grains. Larger cereal yields are obtainable, which means more food, if the higher productive varieties of these crops and the agronomic components of improved production technology are adopted.

The creation by plant breeders of high yielding varieties combining disease resistance with higher yield potential across different climates represents a major achievement contributing to both greater food production and stability of production.

Many techniques are available to plant breeders to assist them in developing a new variety, which is an improvement over those currently grown. One of these procedures in the overall breeding system is the utilization of an offseason nursery.

THE OFFSEASON NURSERY SYSTEM

The offseason nursery, sometimes called the summer nursery, is a device used for growing two crops of wheat or other small grains within a 12 month period. In practice, this special nursery is grown during the non commercial crop season. It is generally located at high elevations of 2,000–3,000 meters (6,560–9,840 feet) above sea level, in order to provide cooler conditions for plant development.

Benefits from the offseason nursery are limited to spring habit wheats. Commercial spring wheat crops are sown at the beginning of a growing season and develop normally until maturity. They may be either spring or autumn sown, depending on the latitude. In the lower latitudes where frosts do not preclude wheat production in the winter months, they are autumn sown. Their cycle takes 90–150 days.

By contrast in the winter wheats, there is a requirement for a period of low temperature exposure in order to induce them to elongate and produce spikes. The winter wheat crop is sown in the autumn and is not harvested until the following summer—a total time of 10 months. Obviously, it is not possible to grow two crops in one year.

There are three objectives in the offseason nursery system:

1. Advancing breeding material by an extra generation per year

The reduction in the time required to create a new variety significantly speeds up the breeding program. An example to highlight this fact, is the breeding by CIMMYT of a variety which was released in 1976 by INIA of Mexico under the name Pavon 76. INIA is the Instituto Nacional de Investigaciones Agrícolas. By using an offseason nursery at Toluca in Mexico, the material was ready for inclusion in preliminary yield tests as a fixed line in three years from the time of crossing. Seed multiplication was then commenced while the line was carried on for two more years in advanced yield tests. In the absence of an offseason nursery in any plant breeding organization, the time from making a cross to the release of seed to farmers is at least 10 years. Pavon 76 was therefore produced in half the normal time.

Taking into account that the population in the developing countries is increasing by a number in excess of one million persons per week, it is evident that the pruning of five years from a 10 years breeding program, and thereby more quickly advancing a higher producing new variety into the food pool, represents a significant contribution to the supply of food.

2. Screening for diseases and adaptation

Screening is a procedure which allows for the systematic examination of plants to assess their performance under a wide range of disease and climatic conditions. It is evident therefore that to provide the best selection pressures, the offseason nursery should be grown where the climate is different from that of the main plant breeding station and preferably have some other disease pressures. Additionally, as many as possible of the diseases endemic at the main breeding station, should also occur at the offseason nursery site. The successive movement of materials during the segregating generations from one set of conditions to another and back again, provides a severe screening for wide adaptation.

3. Multiplying seed of promising lines

Once a new line has been fixed, and preliminary yield trials have indicated that the line represents a worthwhile improvement, the seed multiplication operations can be speeded up by using the offseason nursery for initial seed increases. It is imperative to have sufficient land at the summer nursery station to do this job adequately.

CIMMYT'S MEXICAN OFFSEASON NURSERY SYSTEM

To advance breeding material two generations per year under strong selection pressures, CIMMYT operates a highly integrated system involving stations at Ciudad Obregon, Toluca and El Batan. (See Box titled "CIMMYT in Mexico" on page 4).

The operation was initiated in the mid 1940's by Dr. N.E. Borlaug when he was working in the Office of Special Studies, a cooperative program between the Mexican Ministry of Agriculture and the Rockefeller Foundation, a program which envisaged making Mexico self sufficient in wheat production.

He reasoned that if he could grow two generations a year—one in northwest Mexico in the Yaqui Valley at 27°N latitude and a second generation at Chapingo at 18°N latitude in central Mexico, he could halve the breeding time. Despite many opposing viewpoints, he began a system wherein he took seed from an April-May harvest in the Yaqui Valley, grew it as a summer crop under different climatic conditions at Chapingo, and then returned the seed harvested from there, back to Yaqui, in time for seeding in the following cropping season.

After six years, he discovered that selections made in this shuttle system, i.e. selection in alternate segregating generations under very contrasting environments, resulted in adaptation to short daylength. He found that the resultant wheat lines were either photoperiod (daylength) insensitive or possessed a considerable degree of insensitivity. It was later shown that such wheats can be grown successfully in spring wheat areas from Alaska to the tropics under either irrigated or rainfed conditions.

Today, the major CIMMYT cereal breeding operation is conducted in the winter season, i.e. commercial crop season, at Obregon (Yaqui Valley), and the summer cycle is grown mainly at Toluca, and to a lesser extent at El Batan.

Each year, a number of integrated operations take place: In **Obregon:** Sowing commences during early to mid November and harvest begins in April and continues to early May. At **Toluca and El Batan:** Later maturing material is sown in the first week of May and all plantings are completed by the end of the month. The harvest period for this season commences in the first week of October and continues to the first week of November.

Stripe rust screening is carried out in rows in the summer nursery at the CIMMYT station near Toluca, Mexico.

CIMMYT IN MEXICO

Some physical characteristics of the three wheat plant breeding stations used by CIMMYT are:

	Cd. Obregon Winter commercial crop season Nov-April/May	Toluca Summer offseason May-Oct/Nov	El Batan Summer offseason May-Oct/Nov
Altitude (m)	39	2640	2240
Latitude (°N)	27	19	19
Area used (ha)	165	48	28

The CIANO-INIA station (Centro de Investigaciones Agrícolas del Noroeste—Instituto Nacional de Investigaciones Agrícolas) is located near Ciudad Obregon in the Yaqui Valley in the State of Sonora. It is here that CIMMYT as a guest conducts its own improvement program with CIANO—INIA. The generation grown there during the winter, i.e. the commercial crop season, is raised under irrigated desert conditions. Leaf rust is endemic in the Yaqui Valley.

The offseason summer highland site at CIMMYT's Toluca station is characterized by heavy rainfall and cool temperatures throughout the growing season. Every year severe epidemics of stripe rust occur. Leaf rust and stem rust are also prevalent and in some years, *Septoria nodorum, Septoria tritici, Fusarium roseum and Fusarium nivale* may be present.

Operations in the other highland site at CIMMYT's headquarters at El Batan are on a smaller scale because of the limited land area available. They are primarily concerned with barley and germ plasm development. Diseases of barley are very well manifested.

Argentina, Brazil, Canada and the U.S.A. grow materials in the offseason nursery operations at Cd. Obregon and Toluca to screen for stem and leaf rusts, and for generation advancement.

Whether harvested seed is moving from the winter operation to the summer operation, or vice versa, the turn around time is very short. Actually, the early planting at Toluca, of harvested seed from Obregon, takes place while the remainder of the Obregon lines are being harvested. However, because the logistics are well planned and geared to move and re-plant the lines, CIMMYT is able to operate and manage a highly successful offseason (summer) nursery scheme and complete two growing cycles within twelve months.

In essence, the winter program at Cd. Obregon allows selection for leaf and stem rust resistance and for yield potential. The summer nursery at Toluca and El Batan advances the generation and allows for selection for resistance to stripe rust, stem rust and *Septoria* leaf blotch at Toluca, and stem and leaf rusts at El Batan.

The CIMMYT system outlined above includes the four crops, bread wheat, durum wheat, triticale and barley, all of which benefit from the general concept of reducing the time to produce a new variety and to broaden the spectrum of disease resistance.

A program of making new crosses is carried out at both locations and in the case of bread wheat alone, about 4000 crosses are made at each location. The F_1 seed obtained is planted at both winter and summer operational sites, respectively. The term F_1 denotes the first generation offspring from a given mating (cross pollination) between any parents.

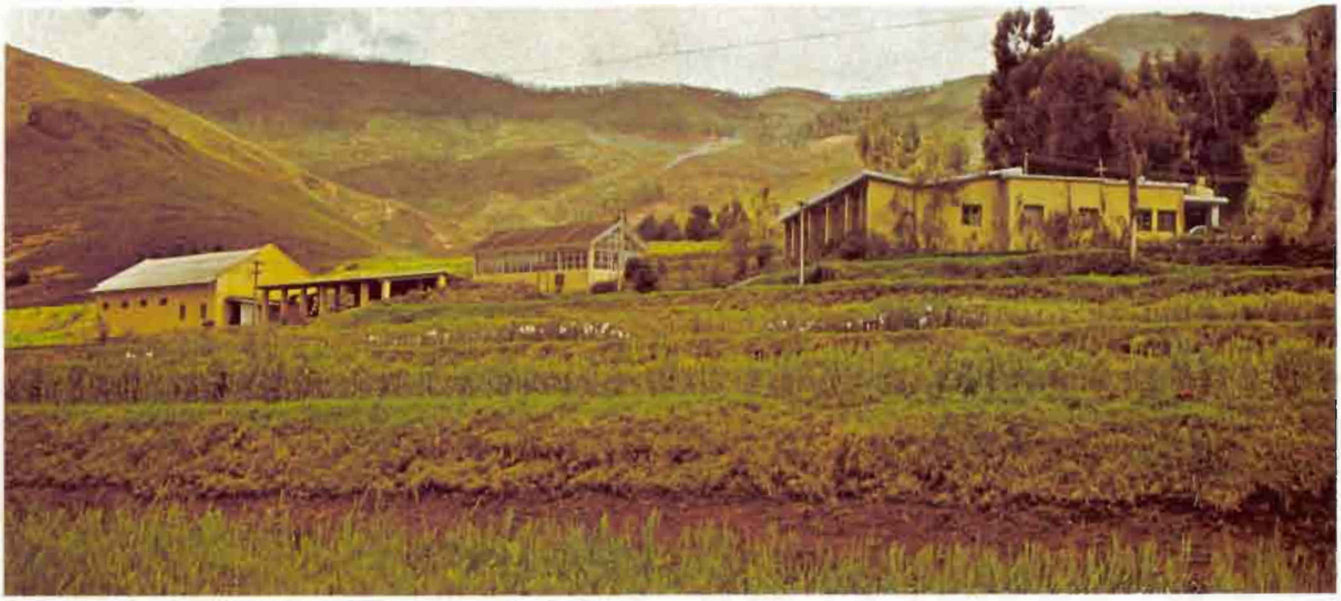
Nurseries which are received from overseas sources are also grown at these sites to assess their resistance to disease and for later incorporation in the crossing programs. An international nursery is a collection of varieties or lines which plant breeders assemble for testing at many locations in order to obtain specific data under varying biological and ecological conditions. International testing is described in CIMMYT TODAY No. 10, "International testing in wheat, triticale and barley".

OTHER OFFSEASON NURSERIES

Several developing countries now operate similar nurseries as part of their national wheat improvement programs. They have followed the pattern established by CIMMYT in evolving its offseason nursery system in Mexico.

Some national scientists, who have been trained at CIMMYT, have been instrumental in establishing offseason nurseries in their countries, on returning home.

The nature and extent of the activities of these nurseries in the developing countries is influenced by the availability of ecological sites suitable for good plant growth, the development of disease epidemics that can be used for screening, the availability of funds, facilities and staff, the strength and needs of their breeding program and the service role which they play in international plant breeding cooperation.



The Wellington Research Station, southern India, is located at an elevation of 1,850 m (6,070 ft) in The Nilgiris hills. It screens material for stem, leaf and stripe rusts.

There are now a substantial number of offseason nurseries being grown in different areas of the world.

INDIA

In The Nilgiri hills in the State of Tamil Nadu, Southern India, the Indian Agricultural Research Institute conducts an offseason nursery at its research station at Wellington. (See Box "India—A Nursery in The Nilgiris", on page 7.)

The Nilgiri hills stand at elevations of 900—2,600 m (3,000—8,500 ft) above sea level, and extend over an area of 2,560 sq. km (990 sq. miles). The summer temperature range is 10—27° C and the winter range is 0—21°C. The average annual rainfall for The Nilgiris is 1,225 mm (48 inches).

It was not until the early sixties, that the Wellington station was used as an offseason nursery in the Indian program for developing disease resistant varieties. Since then, it has played a vital role in the screening of breeding material because new virulent rust races appear to arise in this region.

Materials are screened for stem, leaf and stripe rusts. The region is the chief source of infection for stem and leaf rusts for the rest of India.

The spores of new stem and leaf rust races which develop in The Nilgiris, especially stem rust, are distributed by wind action and attack the wheat crops on the plains one or two years later. Despite the destruction of spores on the plains by high summer temperatures, the new races survive in The Nilgiris on green plants.

Mr. M. Kochumadhavan Menon, station scientist (left) and Dr. P.N.N. Nambisan, officer in charge (right) Wellington Research Station, India inspect a triticale plot where plants have been crossed.

Wellington Research Station staff in India, making crosses among triticale plants.

Although stripe rust is present, spores from this source are unable to move out to infect the northern Indian wheat areas. Stripe rust only occurs in a damaging form in the north, where its source of spores is the Himalayan foothills. It will not live on the southern plains, because temperatures are too high throughout the year.

Barley from Delhi is being grown in rows at the Wellington Research Station, India, for disease screening purposes.

In The Nilgiris however, stripe rust has become an increasing problem since 1975, with most of the nursery entries showing an 80–90 per cent infection level.

The material in the offseason nursery is also subjected to *Septoria, Alternaria and Helminthosporium. Septoria,* which is of little commercial importance in India, has become more severe in the nursery and in some years is sufficiently heavy to allow for selection. However, in the nursery this disease occurs more as a nuisance role. When rains are light there is no screening for *Septoria,* but powdery mildew is normally present throughout the growing season and screening for this disease is facilitated.

About twenty Indian research stations annually send material to Wellington. Each station sends a worker to plant the seed. Later, staff from the participating stations return to Wellington to make observations, select materials and take their own harvested lines back for sowing at their base stations.

The first seed received for planting in the offseason nursery is F_1 seed. If the plants look promising, alternate generation plantings take place at Wellington and the originating breeding station. If it survives the selection pressures and is accepted as a variety it will have been grown at Wellington for three of its generations up to the F_6 stage, i.e. the sixth generation.

Without this offseason nursery operation in India, it would take 10–12 years for a new variety to reach farmers. The Wellington system reduces this to 6–7 years.

INDIA—A NURSERY IN THE NILGIRIS

The reasons in order of importance for conducting the Wellington nursery in India are screening for disease, advancing a generation and multiplying promising lines.

The Wellington station was commenced in 1954. It is located at latitude 11°N and longitude 77°E. The altitude is 1,850 m (6,070 ft). The temperature range is 5—27°C and the average annual rainfall is 1,500 mm (59 inches). The soils are lateritic with poor water retention properties. The area in use is 17 hectares (42 acres), but it is hoped to extend the area.

The growing period for the offseason nursery is from May-June to September-October during which time approximately 350 mm (14 inches) of rain are received. At present there is no irrigation system at the station and consequently the planting time for the nursery depends on the arrival of the monsoon. The nursery trials are mainly sown in June. Occasionally, planting may commence in late May. It takes about five months to reach harvest in October, which can be a very wet month. The harvest in October permits the seed to be sown on the plains in November, where the plants are then screened for agronomic characters. The growing cycle on the plains commences with planting from the first week of November-mid December, with harvest in April-May.

The screening work at Wellington encompasses bread wheat, barley, triticale and some durums from Central India.

Before any material from overseas programs can be grown at Wellington, it must first be screened at stations on the plains to prevent the introduction of exotic diseases into The Nilgiris. For example, the 9th International Triticale Yield Nursery and the 9th International Triticale Screening Nursery from CIMMYT were first planted in December 1977 at Bangalore. The seed harvested therefrom was planted at Wellington in July 1978.

India operates another high elevation offseason nursery in the Lahaul Valley of the Himalayas at an altitude of about 3,350 m (11,000 feet). This nursery provides yet another means of increasing selection pressure on materials being developed under a still different environment.

IRAN

Iranian plant breeders use an offseason nursery at Kelardasht (See Box "Iran—Crop Trials at Kelardasht", page 8), to obtain two generations a year in their breeding program and to screen for disease resistance. The nursery is not used for seed multiplication since the land area is limited.

The main benefit to Iran is in the acceleration of the breeding program. The nursery reduces the time for the production of a new variety from 12—15 to seven years in this case.

The second important benefit comes from disease screening. Stripe rust is prevalent at Kelardasht. This disease is the number one problem in Iran. It is principally a problem in winter wheats, which constitute two thirds of Iran's wheat production, but it can be very important on spring wheats in the Caspian region. Stem rust is also an important disease, mainly in spring wheats. Common bunt is important in the winter wheat areas and loose smut in the spring wheat zones.

Other diseases include leaf rust, *Septoria,* powdery mildew, *Helminthosporium,* and barley yellow dwarf virus. Many of these diseases other than yellow rust are screened in the normal winter nurseries.

During the summer cycle, plant breeders from different areas visit the station to select and screen their materials.

Dr. Mohammad Ali Vahabian, plant breeder (left), discussing offseason nursery results with Dr. Hussein Kaveh, Wheat Coordinator (right) at the Seed and Plant Improvement Institute, Karaj, Iran.

IRAN—CROP TRIALS AT KELARDASHT

The nursery station which was commenced about 1964–65 is the only offseason nursery in Iran. It is located at latitude 37°N and longitude 51°52'E, at an altitude of 1,100 m (3,610 ft). Its position is on the western side of the Elburz Mountains. The experimental area is approximately 20 hectares (50 acres).

The average annual rainfall is 500 mm (19.7 inches) of which 350 mm (13.8 inches) falls in the commercial farm cropping season, i.e. October-July, and 150 mm (5.9 inches) in the nursery period. Maximum temperatures range from 35–40°C (95–104°F) in July. The lowest minimum winter temperature is approximately −5°C (23°F). The station is covered in snow to a depth of 25–50 cm (10–12 inches) from late December/early January to March.

Spring wheat material which is harvested at the Ahvaz Station in southern Iran during late March-early May is promptly taken to Kelardasht where it is planted in the offseason nursery by mid May. It is harvested in the late August-early September period. If wet weather delays planting later than mid May, a poorer crop results —the plants have smaller and fewer tillers (only 1–2), and consequently total seed production is reduced.

The commercial cropping season used by farmers in the district commences with planting in late October-early November and ends with harvest in July.

Under cool humid weather conditions, very good epidemics of stripe rust are encountered at Kelardasht, whereas at the dry area station at Ahvaz, epidemics occur once every 3–4 years.

PAKISTAN

Pakistan has an offseason cereal nursery station located in the Himalaya Mountains at Kaghan, where breeding material is screened for stripe, leaf and stem rusts, in that order of importance. Material is grown there from research stations in all four provinces viz, Punjab, Sind, Baluchistan and North West Frontier Province and in addition from the Pakistan Agricultural Research Council (PARC), Islamabad. (See Box "Pakistan—Contagion at Kaghan", page 9).

When plants reach the heading stage, plant breeders and pathologists from provincial research stations are notified by telegram so they may go to Kaghan to make their crosses. When the plants are mature, they revisit the nursery to make selections and to harvest the seed, for normal season planting. Most of the material which is screened at Kaghan has already been grown at the provincial stations.

Pakistani scientists regard disease screening as the prime objective of the nursery, followed by the advance-

Mr. Mohammad Bashir, assistant research officer (left), Mr. Ehsan-Ul-Haque, assistant plant pathologist (center) and Mr. Bakht Roidar Khan, wheat agronomist (right) take notes on wheat leaf rust in the Kaghan offseason nursery, Pakistan.

The Wheat Coordinator in Turkey, Dr. Basri Devecioglu (left) and the Wheat Breeder, Dr. Polat Solen (right) with one of the promising new spring wheat strains being developed at the Aegean Regional Agricultural Research Institute near Izmir, Turkey.

PAKISTAN—CONTAGION AT KAGHAN

An offseason nursery is located in Pakistan at Kaghan because maximum rust development occurs in this region in the Himalayas. Material is screened for stripe, leaf and stem rusts. The latter is carried over on volunteer and self-sown wheat, and possibly on some grasses.

The station was established about 1972. It is positioned next to the Kunhar River and it is located at latitude 34°78'N and longitude 73°57'E, at an elevation of 2,039 m (6,689 ft). It is located at the bottom of a valley surrounded by mountains several thousand feet high.

Maximum and minimum temperatures respectively are 15–20°C (60–70°F), and –23°C (–10°F) with snow to a depth of 10 feet present from late October to March. May and June are the rainy season months followed by drizzle in July and August.

The nursery is sown from the last week of May to the first week of June, and harvest is from the second to the fourth weeks of September.

The total area of arable land is 9 hectares (22 acres). Wheat, barley, triticale and to a lesser extent chickpea (gram), potatoes and maize are tested.

Nurseries and breeding material from such organizations as CIMMYT, ICARDA, Nebraska and Oregon State Universities (Winter x Spring lines) and the USDA are screened at Kaghan. The best of this material will be used by local cereal breeders to benefit the national cereal program.

ment of a generation and finally, the multiplication of promising lines. The presence of a summer nursery operation enables the early detection of a new rust race. This is an important feature since it means that the screening is applicable to future, as well as to present advanced generation material.

The normal length of time required to produce a new variety in Pakistan without an offseason nursery operation is 10 or more years. The presence of the Kaghan nursery reduces it to five.

TURKEY

In Turkey, two situations exist which limit or preclude the use of an offseason nursery system in the plant breeding program.

The first obstacle relates to winter wheat. On the Anatolian Plateau, the crop cycle (10 months) for winter wheats is long. The wheat crop is sown during the first three weeks of October and is not harvested until late July-early August in the following year. The time gap

Mr. Nasir Ali Jaffery, assistant research officer (left), and Mr. Nazar Hussain Khan, wheat botanist (right). Both are visiting Kaghan from the Agricultural Research Institute, Tandojam, Sind, Pakistan to identify and examine their wheat breeding material prior to threshing for seed recovery.

before the next cropping season is only two months. This fact, and the need to vernalize the seeds, make it impossible to use a summer nursery system, as is the case with winter habit cereals in general. In the vernalization process, seeds are germinated and subjected to near freezing temperatures for about six weeks. The transformation which takes place during this period changes the winter habit to a spring habit and allows the plants to head normally.

The second problem relates to the Aegean Regional Agricultural Research Station at Menemen, near Izmir, participating in the screening of spring wheats under intense disease pressure conditions at Njoro, Kenya.

Sowing is carried out at the Institute from mid November and harvest occurs from late May-early June. This seasonal harvest time makes it difficult for Turkey to send segregating material to Njoro, Kenya, where the planting time is May-June. Often the segregating material at the Institute is not harvested until mid June-early July. Thus only a limited number of materials may be submitted in some years.

The Institute is located at approximately 38°15′ N latitude and 27° E longitude, at an elevation of 10 m (33 ft). The average annual rainfall is 600–700 mm (24–27.5 inches) which falls from late October to the end of April. There is no rain from May-October. The minimum temperature is −3°C (27°F) and the maximum is usually about 39°C (102°F), but can reach 44°C (111°F) in July-August after harvest.

This Institute is the central and largest station of the spring wheat part of the Turkish national cereals project. Its main objective is to produce segregating material for distribution to other stations which in turn select the best lines for their region, after disease screening and yield testing. The other objective is to breed resistance to the major diseases—stem, stripe and leaf rusts, powdery mildew and *Septoria tritici.* Sources of resistance to loose smut and common bunt are also being sought. Loose smut is becoming a more important disease.

Turkey does send its spring wheat screening nurseries and crossing blocks to Kenya, Mexico, Ecuador (Quito) and other countries which enables the program to collect disease and adaptation data on its materials from those sites. A crossing block is a nursery consisting of carefully selected lines of potentially valuable parents for use in national cereal breeding programs. So, although Turkey does use international nurseries to screen advanced lines for diseases and adaptation, the time factor disability prevents segregating material in the main from going to these nurseries for advancing a generation to reduce the breeding time in the program.

ICARDA

In January 1977, a new agricultural research organization, the International Centre for Agricultural Research in the Dry Areas, ICARDA, was formed to conduct research and training to increase and stabilize food production in the Near East and North Africa. ICARDA is developing a new field station of 948 hectares (2,340 acres) at Tel Hadia, which is located 30 kilometers (18.6 miles) south west of Aleppo in Syria.

One of ICARDA's programs is the improvement of cereal crops, and in this area it is active with offseason nurseries. Much of its work, especially that concerned with wheat, triticale and barley is carried out in close cooperation with CIMMYT. Material is being sent to the offseason nursery in Kenya for disease screening.

ICARDA has also used a nursery at Shoubak in Jordan, for advancing material and there is some possibility of using another advancing nursery near Sergaya, which is located in the mountains west of Damascus. ICARDA is screening for diseases, under artificial conditions at its own field station at Tel Hadia, Syria, but the dry atmosphere and low rainfall have proved to be an obstacle to good development for certain diseases.

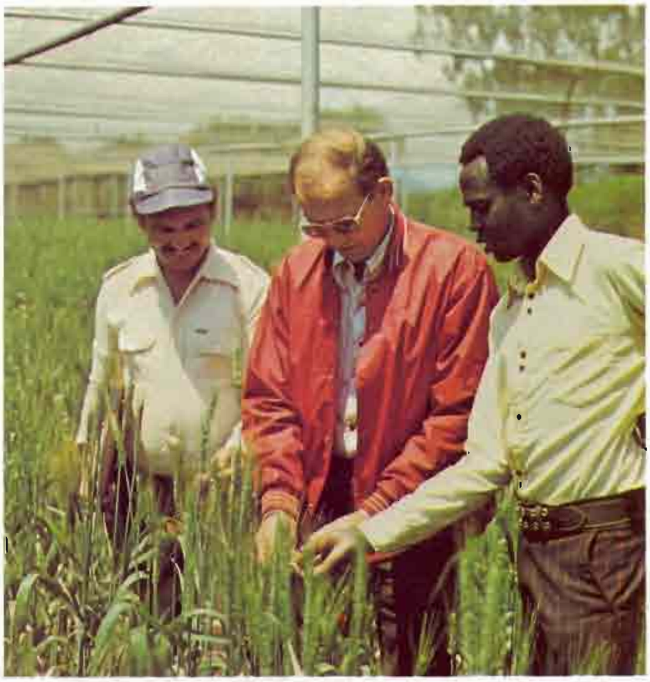
At ICARDA, Aleppo, samples of bunt infected wheat are examined by Dr. A. Hadjichristodoulou, barley scientist (left), and Dr. A.H. Kamel, cereal pathologist (right).

Some laboratory buildings at the National Plant Breeding Station, Njoro, Kenya. The station was established in 1927. CIMMYT screened over 23,000 lines at this station in 1978.

There are many important wheat diseases in the regions in which ICARDA operates. In north and north eastern Syria, the principal diseases are the three rusts. In North Africa, Saudi Arabia, South Yemen, North Yemen and Oman, the three rusts are very important. *Septoria* is prevalent mainly in North Africa and along the eastern Mediterranean coasts. Scald and *Helminthosporium* spp. are important diseases on barley everywhere in the region. Other barley diseases of importance are the three rusts, powdery mildew and smut. In Iraq, Syria and Iran, loose smut is widespread.

KENYA

The highlands of Kenya are world famous for the broad spectrum of virulent races of the stem rust pathogen, which evolve there. Recently, stripe rust has also become important. Wheat farmers in East Africa have experienced devastating epidemics of stem rust in wheat varieties for many years. The need for an improvement program was recognized earlier this century and a breeding program was established at Njoro, Kenya in 1927. Since then many varieties have been released, which not only made the Kenyan wheat industry successful, but also gained for Kenya, recognition as a source of stem rust resistance for the world.



International plant breeding activity and cooperation at Njoro, Kenya. From left: Mr. Moussa Mosaad, plant breeder, Egypt; Dr. Gerbrand Kingma, breeder, CIMMYT; and Mr. Alfred Tarus, Kenya, examining bread wheat hybrids made in Egypt. This breeding material is being grown at Njoro tô advance it an extra generation for the Egyptian breeding program.

Dr. Matthias Oggema, Director, National Plant Breeding Station, Njoro, Kenya. He is enthusiastically devoted to the use of the offseason nursery system, everywhere.

Climatic and high elevation conditions favor rust infections and the evolution of rust races. Resistant varieties commonly become susceptible to new races in a few years. This situation in Kenya has been used as much as possible by national and international breeders for testing their materials against rusts. Prior to 1975, the personnel and physical facilities were generously provided by the Government of Kenya at the Plant Breeding Station at Njoro.

Because the amount of material being sent there was increasing and also to assist the expansion of the facility, the Kenyan Government provided CIMMYT with an opportunity to reach a more permanent arrangement by establishing a base for an East African Regional Program. Dr. Gerbrand Kingma was appointed to Kenya in 1976, as Breeder to head the program. The CIMMYT involvement was financed for the first three years by a grant from the Canadian International Development Agency. In early 1979, the Netherlands Government appointed an assistant plant pathologist, Dr. H. Bonthuis, to assist Dr. Kingma monitor disease developments in the East African region.

This Kenyan facility not only serves Kenya and other countries in Eastern and Southern Africa, but it also assists many developing countries in the Mid East, which do not possess ecological sites suitable for developing offseason nurseries.

Consequently, many cereal breeders now use the expanded testing service. Each year, thousands of introductions from other cereal areas of the world are screened at the Njoro Station. (See Box "The Kenyan Connection" on page 13.) All experimental lines developed in Mexico for example, are screened in Kenya.

The use of this summer nursery enables generation advancement of breeding material, selection for new sources of resistance under severe disease pressure and if required, selection for daylength insensitivity due to the fact that the Njoro Station is 2^{o} South of the equator. Diseases and adaptation of the F_3–F_5 generation materials form the basis of selection.

Countries which have sent seed to be grown at

THE KENYAN CONNECTION

The Njoro National Plant Breeding Station in Kenya was commenced in 1927 and it is one of the oldest experiment stations in Africa. It is located about 200 km (124 miles) northwest of Nairobi and is 25 km (15.5 miles) west of the town of Nakuru, at an altitude of 2,164 m (7,100 ft) and at latitude 02°15'S and longitude 35°57'E.

The average annual rainfall is 938 mm (37 inches). The sequence of highest monthly rainfall in descending order is April, August, May, July. In the main season, the nurseries are usually planted in the April-mid June period, but later plantings are also successful. About half of the total annual rainfall is received during the period May-September inclusive. The nurseries are therefore grown as rainfed crops.

The nurseries are normally harvested from mid September to late October so that seed can be returned to the participating countries for seeding by the plant breeders at the end of November.

To further examine the performance of material in the Kenyan high elevation environment, repeat nurseries are also planted at Njoro in the October-November period. Actually for Kenya, this is an offseason nursery operation. The material is harvested in March.

A substation for cereal research is located at Molo, which is 50 km (31 miles) from Njoro. The average annual rainfall at Molo exceeds 1,200 mm (47 inches) and the altitude is 2,804 m (9,200 ft), which is the highest area in Kenya where wheat and barley are grown. Sowing usually occurs in July.

The highlands of Kenya exert a heavy disease pressure on cereals. In the case of **bread wheat,** stem rust *(Puccinia graminis tritici)* and stripe (or yellow) rust *(Puccinia striiformis)* are particularly important. Other wheat diseases of importance are leaf rust *(Puccinia recondita tritici), Septoria spp., bunt (Tilletia spp)* and loose smut *(Ustilago nuda).*

The major disease of **barley** is leaf scald *(Rhyncosporium secalis),* followed by spot blotch or leaf spot *(Helminthosporium sativum)*and stripe (or yellow) rust *(Puccinia striiformis).* The two rusts viz., stem rust *(Puccinia graminis)* and leaf (or brown) rust *(Puccinia hordei),* and loose smut *(Ustilago nuda)* are usually of little importance.

In the case of **durum wheat,** the most important disease is stripe rust *(Puccinia striiformis).* Stem rust *(Puccinia graminis tritici)* occurs to a lesser degree.

There are several diseases present which infect **triticale.** The most severe is leaf blotch *(Septoria avenae triticea and Septoria nodorum).* A disease which can be serious is leaf necrosis or leaf spot, *(Helminthosporium sativum and Helminthosporium tritici repentis).* Other diseases are stripe rust *(Puccinia striiformis),* leaf rust *(Puccinia recondita)* and stem rust *(Puccinia graminis tritici).*

Njoro include Algeria, Andean Region (Ecuador, Peru, Bolivia and Colombia), Cyprus, Egypt, Ethiopia, Greece, Iraq, Jordan, Lebanon, Mexico, Nigeria, Oman, Pakistan, Portugal, Spain, Syria, Tunisia, Turkey, U.S.A. and also the ICARDA organization.

Dr. Kingma assisted by Dr. Bonthuis administers and supervises the planting, the recording of disease and other data, plus the harvest and the return of information and/or material to the participants. Two CIMMYT scientists, viz., Dr.J.M.Prescott (Wheat Pathologist, Turkey) and Dr. E.E.Saari (Plant Pathologist, Wheat Program, Egypt) visit Njoro each year for 3–5 weeks to assist Dr. Kingma record disease data and to visit other countries in the region. Close cooperation is maintained with ICARDA, whose scientists also work directly with many of the countries which use offseason nurseries.

The size of the operation can be measured by the fact that in 1978 over 23,000 entries were sown. The disease pressure is so great at Njoro that of these, only 1,775 introductions survived (7.7 per cent). Yield nurseries

Only a few seeds of the F1 generation are available from each cross for planting in the CIMMYT nursery, Njoro. Each lot of F1 seeds is planted as a group in a "hill" (as opposed to rows), to conserve nursery space.

Wheat plots at the National Plant Breeding Station, Njoro, Kenya. The variety (left) is K. Swara showing stripe rust infection in the head (yellow color) and in the leaves. By contrast K.Kanga (right) is resistant and the plants are still green.

of bread wheat, durum wheat, triticale and barley were grown. Other nurseries included the Stem Rust Parental Nursery, the Stripe Rust Parental Nursery, the Mid East Regional Disease and Insect Screening Nursery, the Regional Disease Trap Nursery and the Screening and Yield Nurseries of the African Cooperative Wheat Trials, as well as all CIMMYT's international materials.

Participants are requested to inform Dr. Kingma whether they require only disease data on the lines being screened or whether they wish only to have the lines advanced by a generation and harvested seeds returned to them with disease reactions, if possible. Only promising materials are returned to the cooperating breeders.

There are many problems in moving seed expeditiously to Njoro. In 1978, Dr. Kingma provided a greater certainty of obtaining the seeds on time, by visiting many national programs in the Middle East and personally collecting the seeds intended for testing.

The materials grown are F_1–F_5 generations, that is the first to the fifth generation after cross pollination. In the F_1, the number of seeds provided ranges from 5–10. Because thousands of lines are planted each year, the F_1 seeds are planted in "hills" in order to conserve space for planting F_2 and other generations. Each hill contains 4–8 seeds and 50 hills are placed in a row.

One advantage of hill planting in the first year, is that it allows for the possibility of eliminating many susceptibles while devoting only limited land to the F_1 plants. With segregating generations however, more land is required since these are space planted in a row.

It is customary for the participants to send only a portion of their F_1 seeds. When the results for the F_1's grown in Njoro are returned to the breeder, this information can be used by them when they are growing the balance of the F_1 seeds in their normal crop season.

The Kenya-CIMMYT operation in Njoro offers other benefits to plant breeders apart from those available in this offseason nursery system. For instance, every year CIMMYT brings breeders from cooperating Mediterranean countries to Njoro (at CIMMYT's expense) to examine their own materials and observe all the other lines being grown. They gain a valuable insight into the international exchange of germ plasm and also learn that their own materials when exposed to the stress situation of the Kenyan Highlands may look very different from their appearance at home. Whole new dimensions in their breeding programs are revealed to them.

Another benefit stemming from the nursery operation comes from holding workshops at Njoro. In 1977, scientists from 11 East African nations attended a workshop on wheat and triticale development funded by the International Development Research Centre (IDRC), of Canada. The 1978 workshop on cereal rust methodology was attended by 13 persons from several East African countries. This workshop was funded by the Government of the Netherlands and was conducted jointly by IPO, the Institute for Plant Pathology Research at Wageningen, and CIMMYT.

SOME PROPOSALS AND VIEWPOINTS

Dr. M. W. Oggema, Director of the Njoro Plant Breeding Station in Kenya, very strongly supports offseason nurseries and would like to see more use made of this procedure to speed up breeding programs. He said "the holding of an international nursery workshop from time to time by international organizations like CIMMYT, on the establishment, management and benefits of the offseason nursery operation would be most advantageous. Persons would return to their home country stimulated and motivated". He also has strong views on the need for national programs to develop vigorous seed production organizations.

Dr. J. P. Srivastava, Cereal Improvement Program Leader, ICARDA, Aleppo wants to see more countries participate in the Kenyan nursery operation, and to be involved **every** year. He also believes that an effective way to stimulate countries is to discuss offseason nurseries at international cereal conferences attended by scientists and administrators. Also, national and international organizations should make more funds available to finance the sending of scientists to Kenya from those countries which do not participate in the nursery at the present time, in order that they may learn some of the advantages.

At the Plant Improvement Institute at Karaj in Iran, Dr. Hussein Kaveh considers that an international workshop on offseason nurseries would be an excellent education, expecially for young scientists in developing countries. If facilities to operate a nursery do not exist in any particular country, he recommends that that country should contract or cooperate with another country to screen material for it.

In India, Dr. P.N.N. Nambisan, Officer-in-Charge of the Wellington Research Station supports this cooperative proposal where countries do not have their own facilities. To help persons realize the value of the offseason nursery he said "I would tell them of the benefits and achievements at the Wellington nursery, especially that with our operation we can screen against new rust races evolving in The Nilgiris, before they reach the major wheat production areas of India".

Dr. C. Dutlu, Plant Pathologist and Dr. P. Solen, Plant Breeder, at the Aegean Regional Agricultural Research Institute near Izmir in Turkey both agree that offseason nursery workshops and conferences have a great deal to offer. They believe it to be essential that administrators as well as scientists should attend these workshops in order that administrators be made aware of the importance and need for such nurseries to be an integral part of the national breeding program.

To obtain all the maximum benefits from the three integral elements of the system, i.e., generation advancement, disease screening and seed multiplication, the plant breeding program must be a strong one. A weak, small or intermittent program cannot attain the potential 50 per cent saving in time to produce a new variety.

Unfortunately, there are a number of factors which reduce the full utilization of the system. They include ignorance of the value and benefits; attitudes too rigid to break from tradition; antipathy and indolence towards growing two cycles a year; inadequate funds, facilities, staff and technical information; weak administration; bureaucratic restrictions which prevent national scientists from visiting active offseason nursery programs; and quarantine. When seeds are returned from overseas nurseries to some originating countries, scientists therein are prevented by their own quarantine laws from using the returned material.

THE FUTURE

The offseason nursery system has undeniably demonstrated its very significant role in the faster production of better, new cereal varieties. It was an intrinsic component in the development of the semidwarf spring habit wheats which were instrumental in part, for the Green Revolution.

When practiced on an international scale, its distinctive characteristics are mobility and worldwide cooperation between nations.

These nurseries can be a unique vehicle for conveying promising advanced lines from national and international breeding programs into contact with many different races of dangerous pathogens that exist in different geographic areas of the world. By doing so, the lines with unusually broad types of resistances can be identified.

As we go into the future, world population will increase the pressure for additional food. The impact of the population growth on grain requirements is indicated by the following statistics (CIMMYT Review 1978, p 5). These figures show the actual and projected millions of metric tons consumption per year by the developing countries:

1975	425 million tonnes
1985	550 million tonnes
2000	700 million tonnes

To help to meet this need, cereal yields must be improved and disease and insect losses reduced. In this regard, the offseason nursery system has an essential role to play and it must be used more and more and more. . . . .

J. V. Mertin

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