

**International Institute of Tropical Agriculture**

**CROP IMPROVEMENT  
DIVISION**

**Grain Legume Improvement  
Program**

**Part I. Cowpea Breeding**

**Archival Report (1988–1992)**

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## 1. INTRODUCTION

Since its inception in 1967 until 1985, the International Institute of Tropical Agriculture (IITA) made considerable progress in improving cowpea varieties. It developed and distributed a range of improved breeding lines combining multiple disease and insect resistance with early maturity and preferred seed types to over 60 countries. About 45 countries have systematically evaluated the improved materials received from IITA, identified superior lines and released them for general cultivation. However, all of these lines require 2-3 sprays of insecticides to protect against flower thrips, pod borer (*Maruca*) and pod sucking bugs (PSB). This is due to lack of availability of germplasm lines with high levels of resistance to these pests. Most of the traditional farmers do not use chemical protection due to socio-economic and infrastructural constraints even though the new varieties, when sprayed, can yield between 1 to 2 MT/ha and give high economic returns. They continue growing cowpeas as an intercrop with millet and sorghum in the traditional manner without insecticide. Therefore, during the strategic planning review of IITA's research program in 1986, it was suggested that the cowpea breeding objectives should be diversified. The revised aims included systematic improvement of traditionally cultivated local varieties as well as development of a range of new improved cowpea varieties which would produce higher grain as well as fodder yields in the traditional intercropping systems which are so widely prevalent in the Central and West African Savanna and also in parts of East and Southern Africa. This revision led to: (1) The re-orientation of cowpea breeding objectives onwards from 1989 and (2) The establishment of IITA Kano Station in 1989. The major focus of the program has been to study traditional cropping systems, identify cowpea production constraints and, in collaboration with national programs, develop improved cowpea varieties combining disease and insect resistance with better adaptation and high yield potential under intercropping systems of savanna ecologies where soils are poor and moisture is limited. This report describes the different aspects of research undertaken during the last five years.

## 2. STUDY OF CROPPING SYSTEMS

The cropping systems are diverse and not only differ from region to region but also from farmer to farmer within the same region. It is essential, therefore, to understand the systems and identify major constraints that limit cowpea yields in these systems so that a breeding strategy could be developed for improving cowpea varieties specifically suitable for traditional intercropping. A general survey of cropping systems in the West and Central African Savanna was done in 1988, 1989 and 1990 covering Nigeria, Benin Republic, Niger Republic, Togo, Cameroon and Burkina Faso where cowpea is widely grown. A list of major cropping systems in different ecological zones cutting across these countries is presented in **Table 1**. In the forest and southern Guinea Savanna zone, cowpea is intercropped primarily with maize, cassava and yam and the major constraints are several diseases, and insect pests as well as poor seed quality. Cowpea is intercropped with groundnut, and/or sorghum in the Northern Guinea Savanna and major constraints are several diseases, insect pests and *Alectra*. In Sudan Savanna, cowpea is intercropped with millet and sorghum with or without groundnut. The key constraints are bacterial blight, *Striga*, *Alectra* and insects such as aphid, bruchid, thrips, *Maruca* and PSB. Millet-cowpea intercropping is the only system prevalent in the Sahelian region and the main yield reducing factors of cowpea are ash-stem blight, bacterial blight, aphid, thrips, bruchid, PSB and *Striga* as well as moisture stress and poor fertility.

The broad observations of 1988-90 needed quantitative assessment of the most important cropping systems. In 1991 this major study was initiated by the technical staff of the cowpea breeding group. The study covered 14 farmers' fields in Minjibir and Gezawa Local Government Areas of Kano State (Nigeria) which is the heart of cowpea growing region in West and Central Africa. A 20 m x 20 m block was studied in each field and detailed notes were taken on field history, land preparations, crops and varieties planted, dates of planting, planting patterns, diseases, insects, maturity, harvesting and yields of grain and fodder. This gave a quantitative description of different systems and their constraints which will help to sharpen research focus. Preliminary results show that farmers intercrop two types of cowpea varieties in alternate rows with millet and/or sorghum in the same field - one for grain and the other for fodder. Both varieties are photosensitive, spreading types but the grain type is earlier in maturity and planted earlier than the fodder type. Millet is planted first at the onset of rains (May-June) in wide rows (1.5-3m apart) with 1m hill to hill

distance within the rows reaching about 4000 to 6000 hills per hectare. Early cowpea varieties are planted between millet rows at a hill to hill distance of 1m when the rains are more stable towards June end. Fodder type cowpea is planted later in mid-July between the remaining alternate millet rows. Sorghum and groundnut can either replace or supplement millet and early cowpea rows giving a more complex mixture. However, the most predominant practice in the study area was millet- early cowpea for grain - millet - late cowpea for fodder as shown in Fig. 1. The yield estimate of different crops for each farmer's plot are presented in Table 2. The yield of early cowpea ranged from 23-173 kg/ha except for the plot which recorded 405 kg/ha due to insecticide application but the late cowpea did not yield any grain. The millet yield ranged from 693-1858 kg/ha, sorghum yield ranged from 105-2150 kg/ha and groundnut from 38-270 kg/ha. However, as mentioned earlier not all crops were present in each field. Thus, the average grain yield of cowpea was 110 kg/ha with about 1200 kg/ha of millet or 937 kg/ha of sorghum and with a great variability in the fodder yield. The total biomass ranged from 2.35 t/ha to 1452 t/ha (thickly planted late sorghum). Principal constraints for cowpea production were insects primarily *Maruca*, low population and competition with cereals. Even though the findings of a study of this type may differ from year to year due to variation in weather, pests and other factors, the preliminary data indicate that the average cowpea grain yield under traditional intercropping systems is about 100 kg/ha in the Kano area. This provides a crude base line for establishing target yields of improved cowpea varieties under intercropping.

Building on the 1991 results, and with a multidisciplinary team covering agronomy, entomology and pathology a very detailed study of 36 farmers' field was conducted in 1992. The results were similar to 1991 except that cowpea yields were very low due to heavy *Maruca* damage ranging from 0-40 kg/ha.

### **3. BREEDING AIMS AND STRATEGY**

#### **3.1 Aims**

Based on the survey of cropping systems, it was apparent that cowpea breeding should include the following aims:

- (1) Develop grain, fodder and dual purpose varieties
- (2) Develop varieties for intercrop as well as pure crop
- (3) Combine resistance to aphid, bruchid, thrips, *Maruca*, PSB, *Striga*, *Alectra*, bacterial blight, nematodes, false smut, *Septoria*, scab and brown blotch in a range of varieties and plant types to fit in different croppings systems of savanna ecologies
- (4) Combine drought, heat and shade tolerance in improved varieties for Northern Guinea and Sudan Savannas and the Sahelian Region
- (5) Develop cowpea varieties with inherent capacity to make normal growth under low concentrations of nutrients in the poor soils of the Sahelian Region

#### **3.2 Strategy**

In view of the long list of aims listed above the following strategy was developed to make maximum progress within a short time.

- (1) Collect and evaluate local varieties to select the best recurrent parents for the hybridization and backcrossing programs
- (2) Use the best multiple disease and insect resistant breeding lines already available from the on-going breeding program as donor parents
- (3) Screen additional germplasm lines to identify sources of resistance and other desirable traits not available in the two sets of parents mentioned above
- (4) Conduct basic genetic studies to elucidate nature of inheritance of desirable traits
- (5) Use a combination of backcross and pedigree methods to combine desirable traits in traditional varieties
- (6) screen new breeding lines in pure crop with 2-3 sprays, pure crop with no sprays and intercrop with no spray to select improved lines with high yield potential

- (7) Evaluate promising breeding lines in different cropping systems and different locations to study genotype x cropping system x location interaction
- (8) Develop suitable breeding methods for improving varieties for intercropping
- (9) Use farmers participatory evaluation for selection of promising breeding lines for low input technology
- (10) Involve lead national program scientists for testing improved breeding lines in different ecologies
- (11) Distribute elite breeding lines to national programs in the form of Cowpea International Trials

### **3.3 Evaluation of genetic diversity amongst local varieties**

In order to select suitable parents for hybridization, a systematic program was initiated in 1987-88 to visit farmers fields in northern Nigeria covering from Sokoto to Maiduguri via Katsina and Kano and select the best varieties/plants from farmers fields. Invariably all the fields had mixtures in respect of plant types, seed type and maturity. Therefore, individual plants were harvested. In some cases, a bulk sample was brought to the laboratory and different type of seeds were separated as sub-set of the original samples. These were planted in single progeny rows and evaluated for different characters. In 1987-88 over 50 individual plant progenies were evaluated and out of these 5 progenies were resistant to bruchid and were therefore used in the crossing program. Individual plants/progenies from farmers fields during 1989 to 1992 number over 500 and these are currently at different stages of testing.

### **3.4 Hybridization and handling of segregating populations**

Crosses are made among selected parents in the greenhouse at IITA Kano station and F1's are also raised in the greenhouse. The F2 and F3 populations are planted in the field at Kano and selected for plant type, maturity seed type and for resistance to *Striga/Alectra* and bacterial blight. The selected F4 progenies are then tested at Ibadan both in the field (dry season with irrigation) and in the laboratory for resistance to aphids, bruchid, viruses, *Cercospora* and photosensitivity. The F5 progenies are again screened at Kano and the promising lines are bulked for multilocation testing at Mallam Madori, Maiduguri, Niamey and Maradi for drought, heat, *Striga* and *Alectra* and

bacterial blight; at Kano for intercropping and pure cropping as well as *Striga* and bacterial blight; at Samaru for *Septoria* and scab as well as for adaptation to the Northern Guinea Savanna. These locations are indicated in **Fig. 2**. The bulking of the lines is not always done at F5, but at F6 or F7 stage depending upon the uniformity of the progenies for various characters. By using a combination of screenhouse and irrigation facilities, at least three generations are advanced each year which permits a multiple cycle of crosses among selected segregates enabling pyramiding of desirable genes in improved breeding lines.

## 4. VARIETAL TESTING

### 4.1 Varietal testing On-Station

#### 4.1.1 Procedures

The F5/F6/F7 bulk progenies are grouped according to maturity, seed type etc and first tested in an Initial Evaluation Trial (IET). Promising lines are then tested in succession through Preliminary Variety Trial (PVT), Advanced Trial (AVT) and Cowpea International Trial (CIT). The details about these trials are given in **Table 3**. The trials are planted in 4 row-plots which are 4m long and 75cm apart and 20cm hill to hill except for photosensitive, late maturing varieties which are evaluated in 4 row-plots which are 9m long and 1m apart with 40cm hill to hill distance. IET's are evaluated in an augmented design with one replication along with frequent checks. The number and types of variety trials conducted from 1988 to 1992 are listed in **Table 4**. IET's normally include a large number of lines ranging from 30 to over 100 but PVT and AVT invariably have 20 entries including the check (s). For pure crop spray, a maximum of three insecticide applications is made but normally two are sufficient.

#### 4.1.2 Varietal evaluation in pure crop

The grain yield figures of best two to four varieties included in advanced trials from 1988 to 1992 are presented in **Tables 5-9**. Each advanced trial included similar groups of varieties with respect to maturity and seed color. The grain yields show a great range and differ from variety to variety and year to year (**Table 10**). However, on average, the improved early and medium maturing varieties have a grain yield potential of upto 2MT/ha with 2-3 sprays. Most of these varieties combine multiple disease resistance and some also have resistance to thrips, aphid and bruchid either separately or combined. Thus, a good range of choice of varieties for pure crop cowpea cultivation is available from the work done during the last five years. However, efforts are being made to stabilize their yield potential by combining in them resistance to *Striga*, *Alectra* and bacterial blight.

The yield potential of photosensitive early and late varieties (refer **Tables 7, 8 and 9**) is lower than that of photo-insensitive early and medium maturing varieties, even when the crop is protected by insecticides. This is mainly because photosensitive varieties are the spreading type and have

greater interplant competition. Therefore, these should not be grown as pure crop.

#### 4.1.3 Varietal evaluation as an intercrop

Most of the preliminary and advanced trials were planted at Kano in three systems:

- (1) Pure crop with 2-3 sprays
- (2) Pure crop without sprays
- (3) Intercrop with millet and without sprays

For intercropping, millet is first planted in 2m wide rows with 1m hill to hill distance within the rows. About 2-3 weeks later cowpea varieties were planted in between two rows of millet in single row plots with 2 replications. The individual rows were 9m long. The hill to hill distance was kept at 20m for early and medium maturing cowpea varieties and was 40cm for photosensitive late maturing varieties. No insecticide was applied but the fields were kept clean of weeds. Cowpea and millet yields were recorded. The initial screening of cowpea varieties started in 1988 and the promising lines were further screened in the following years. The yield of cowpea ranged from 0-500 kg/ha and most of the varieties yielded less than 100 kg/ha. The coefficient of variability was often very high because of the uneven incidence of disease, pests, shading and lodging of millet in the experimental area. However, some of the varieties consistently yielded better than others. A summary of results obtained in 1991 is presented in **Table 11**. Each trial listed in this table consisted of 20 cowpea varieties. The results show the variability in the performance of cowpea genotypes under intercropping. The lowest cowpea grain yield was 5kg/ha and the highest was 448 kg/ha. Fodder yields varied from 62 kg/ha to 3062 kg/ha with considerable variability from trial to trial. The mean millet yield ranged from 386-885 kg/ha. The three highest yielding varieties for each trial are listed in **Table 12**. These data indicate that with 1:1 ratio for intercropping of cowpea and millet using the best cowpea varieties, grain yields of 150-200 kg/ha of cowpea (together with about 600 kg/ha of millet grain) can be obtained. This is 50-100% better than the average yield estimated at the farmers' fields during 1991 survey of cropping systems. The best varieties for intercropping were IT89KD-381, IT89KD-451, IT88Dm-400, IT89KD-1075, IT89KD-355, IT89KD-391 and IT88DM-363. These along with others were tested at various locations in 1992. A summary of data is presented in **Table 13**.

## **4.2 Variety Testing On-Farm**

### **4.2.1 Farmers participatory evaluation**

Screening varieties for intercropping at an experiment station has major limitations because sites are not representative of the diverse cropping systems and ranges of soil types and fertility levels at which farmers practice intercropping. To reproduce all these conditions at an experimental station is not feasible. Therefore, nine elite grain type varieties were given to a total of 36 farmers (one variety to 4 farmers) in 1992 for evaluation by them following their own systems. This enlarged the test environment and was undertaken in collaboration with Kano Agricultural and Rural Development Authority (KNARDA). The crop was planted by farmers in their traditional system and totally managed by them. However, the yield estimates were done by technical staff using a 10m x 10m sample plot on each farm. The results are summarised in **Table 14**. In spite of the great variability from field to field, these data suggest definite genetic variability among varieties and indicate that farmers participation in variety evaluation should be pursued. However, more replications would further increase confidence in varietal differences. IT89KD-374-57, IT89KD-319 and IT88DM-867-11 appeared consistently better than other test varieties and Dan Ila, the local variety. Farmers were very happy with these varieties and wanted to participate in the trial next year.

## **4.3 Breeding Cowpea Varieties for Intercropping**

### **4.3.1 Background**

The study of traditional cropping systems in the West and Central African savanna indicates that farmers grow two types of cowpea varieties - an early maturing type for grain purpose and a late maturing type for fodder, often in the same field planted in alternate rows as intercrops in millet and/or sorghum. Both types of varieties are photosensitive but different in maturity. The apparent limitations in currently grown local varieties are their susceptibility to many insects and diseases and very late maturity of fodder type varieties. This gives rise to premature drying if the rains stop early in September. The early maturing grain type varieties like Dan Ila, Dan Wuri and Jan Wake are normally planted by June end and mature by the first week of September, whereas late fodder type varieties such as Kananado and IAR 1696 are planted in mid to late July and they flower in October. In case there are late rains, these varieties will produce some grains otherwise they will be harvested green and rolled into bales for fodder as soon as they show signs of wilting. Interestingly, most of the

early grain type varieties are susceptible to leaf diseases and they disintegrate in the field and are seldom harvested for fodder. The average yield of grain type varieties ranges from 0-150 kg/ha depending upon insect pressure, cropping system and variety. Results of varietal screening in intercropping suggest that indeterminate and spreading type growth habit is essential for good performance since this minimizes insect damage and also permits cowpea plants to avoid competition for light. Therefore, even though a range of varieties are being tested under intercropping, the breeding efforts are being concentrated on improving photosensitive spreading type varieties for intercropping.

#### 4.3.2 Variety development

Two approaches are being followed for variety development:

- (1) Defect elimination. The improvement of selected local varieties by incorporating resistance to aphid, thrips, bruchid, *Striga*, *Alectra*, and relevant diseases by backcrossing
- (2) New varieties. Development of completely new photosensitive spreading type varieties by standard methods using relevant parents

#### 4.3.3 Outputs

Dan Ila (Kano), Jan Wake (TN 5-78, Maradi) and Kananado selection (Kano) were crossed with IT84S-2246-4 and backcrossed to local parents. IT84S-2246-4 is the most promising multiple disease and insect resistant variety developed by IITA which has been formally released in Nigeria. It combines resistance to aphid, bruchid, thrips and several diseases. Therefore, this variety is being used as a donor parent for many desirable genes. From the above backcross populations, promising lines have been developed which look like local varieties but combine aphid, thrips, and some have bruchid resistance also. The most promising among these are:

IT88D-867-11 This is derived from the cross IT84S-2246-4 x Jan Wake<sup>2</sup>. It looks very similar to Janwake but combines aphid and thrips resistance. Its performance has been very good in the drier regions like Niamey, Maradi and Gumel where Jan Wake (TN5-78) comes from. It has brown rough seed, is early maturing photosensitive and suitable for grain.

- IT89KD-374-57 This is derived from the cross Dan Ila<sup>2</sup> x IT84S-2246-4. It is similar to Dan-Ila but combines resistance to aphid and thrips as well as several diseases. Its performance has been very good at several locations in the northern savanna. It has white seeds, is early maturing photo-sensitive and suitable for grain.
- IT89KD-319 This is derived from the cross Kaokin local<sup>2</sup> x IT84S-2246-4. This looks very similar to Kaokin Local but combines resistance to aphid and thrips and several diseases. It has done very well in the northern savanna. It has white seeds, medium maturity, is non-photosensitive and suitable for grain.
- IT89KD-245 It is derived from the cross IT87F-1772-2<sup>2</sup> (Kananado selection) x IT84S-2246-4. It is very similar to Kananado but combines resistance to aphid, bruchid, thrips and also is about two weeks earlier than Kananado. It has done well as a dual purpose variety.
- IT89KD-288 It is also derived from the cross IT87F-1772<sup>2</sup> (Kananado selection) x IT84S-2246-4 but is as late as Kananado. It combines resistance to aphid, bruchid and thrips and does better than Kanannado both for fodder and grain.

Efforts are under way to incorporate resistance to bruchid, *Striga* and *Alectra* in these varieties. Results for dual purpose variety evaluations in 1990 are shown **Table 15**.

#### 4.3.4 Target yield

When the cowpea breeding program for intercropping was initiated in 1988/89, there were apprehensions as to whether any progress in yield could be made over what farmers already obtain. The quantitative surveys of traditional cropping systems conducted in 1991 and 1992 found an average cowpea grain yield of 50-100 kg/ha. At the same time the best available improved varieties have yielded about 250 kg/ha at the experiment station and 100-150 kg/ha on farmers' field which indicates a definite possibility for genetic improvement of yield potential. But what should be the target yield for the breeding program? An experiment was conducted in 1992 to partly answer this question. The most promising varieties were grown in pure crop, strip crop and intercrop with millet in large plots and all possible care was taken to control weeds and insects so that the true genetic potential for yield would be

expressed. Three insecticide sprays were sufficient to control insects. The strip crop had 4 rows of cowpea flanked by one millet row on both sides (80:20) and the intercrop had cowpea and millet in alternate rows (50:50). The yield data for selected varieties are presented in **Table 16**. IT90k-284-2, IT87D-941-1 and IT90K-59 are early maturing and have erect growth habit suitable for pure crop. IT86D-719 and IT86D-715 are medium maturing with semi-determinate growth suitable for pure crop; and IT89KD-349, and Dan Ila are early maturing, photosensitive with spreading growth habit suitable for intercropping. IT89KD-355 is medium maturing non-photosensitive with spreading growth habit suitable for intercropping in northern savannas. The early erect type cowpea varieties gave the highest yield and had less adverse effect on millet irrespective of the cropping systems followed by medium maturing varieties. The traditional type photosensitive varieties gave poor yields in all systems indicating their inherent low yield potential. However, as discussed earlier, under no insecticide protection, most of the erect type varieties yield less than spreading types under intercrop as well as pure crop. The data for the intercrop treatment in **Table 16** indicate that if insects can be controlled, grain yields level of 400-600 kg/ha are possible for cowpea with about 1500 kg/ha of millet grain. This is very close to theoretical expectations. Therefore, the target grain yield for intercrop breeding is about 400 kg/ha of cowpea with at least 1500 kg/ha of millet grain.

#### 4.3.5 Evaluation of the intercropping breeding method

In order to develop improved cowpea varieties for intercropping should the segregating population be grown under intercrop and selection made there or can they be grown and selected in pure crop up to F5-F6 generation before testing under intercropping? An experiment was initiated in 1990 to answer this question. Two specific crosses were made in 1990 which combined a number of desirable characteristics. Sufficient F2 seeds were obtained and divided into two - half of the F2 seeds were planted out in 1991 under intercrop with millet and other half planted as pure crop, adjacent to each other. At maturity, the best individual plants were selected and harvested separately. F3 progenies were again planted in 1992 under intercrop and pure crop respectively. The individual plants were selected and F4 progenies have been again planted in 1993 following the same method as 1992. This will continue until the lines become homogenous and homozygous (F5 or F6) and then these will be tested in both intercrop and pure crop to ascertain which method is more effective.

## 5. BREEDING FOR INSECT AND DISEASE RESISTANCE

### 5.1 Strategy for insect resistance breeding

Five insects viz: aphid, thrips, *Maruca*, PSB and bruchids are the major pests of cowpea and cause up to 100% yield loss and seed damage when infestation is severe. High levels of genetic resistance to aphid and bruchid and moderate level of resistance to thrips were identified and incorporated into promising lines. However, inspite of large germplasm screening, good sources of resistance to *Maruca* and PSB have not been identified yet. This necessitates 2-3 sprays during the flowering and pod development stages which becomes a bottleneck for the small scale farmer. Therefore, three mutually compatible approaches are followed to develop cowpea varieties which can give reasonable grain yields (500-1000 kg/ha) without spraying:

- (1) High Level of Resistance. To incorporate available resistances to aphid, thrips, and bruchid in all new breeding lines. This is a very important aspect of the on-going breeding program. Promising breeding lines with resistance to these pests are listed in **Table 17** and these are being used as parents in further crosses.
- (2) Low Level of Resistance. To screen breeding lines as well as germplasm lines for field resistance/tolerance to *Maruca* and PSB and initiate a recurrent selection program to build up the low level of resistance in improved lines. Genetic male sterile lines will be used for this population improvement program.
- (3) Insect Escape. To breed for very early maturing varieties with good growth and acceptable seed type which can escape insect damage.

### 5.2 Progress In Insect resistance breeding

As mentioned in Section 2.4.1, all the advanced trials and preliminary trials (if seed is available) are evaluated in pure crop without insecticide application so that lines with even low levels of resistance/tolerance to *Maruca* and PSB can be identified. This work started in 1989 and, over the years, a number of breeding lines have been selected which suffer less damage than others. This may be due to a low level of resistance or less preference by the insects. A few promising lines are listed in **Table 18**. The *Maruca* pressure in 1990 was very high and prolonged which caused low yields but in 1989 and

1991 *Maruca* pressure was much less and only for 3-4 weeks which permitted selection for a low level of resistance. Most of the varieties listed in **Table 18** have moderate levels of thrips resistance. Thus, they all produce peduncles and flowers. If *Maruca* damages the flowers, these peduncles produce another flush of flowers, by which time *Maruca* pressure has lessened and reasonable yields are achieved. Also, if the angle between pods is more, *Maruca* attack is less. The best examples of varieties which have some tolerance of *Maruca* are IT86D-721, IT86D-715 and IT89KD-457. These varieties involve Kambošine Local and TVu946-2E as parents which were earlier identified as resistant to *Maruca*. In case a variety is susceptible to thrips, it does not produce peduncles and flowers and so remains vegetative with zero yield. It is imperative, therefore, to incorporate aphid and thrips resistance before screening for *Maruca* resistance under no spray conditions. This work is a major part of the breeding program. The above named varieties, as well as those identified to be moderately resistant from germplasm lines by the PHMD Entomologist, are used as parents.

In parts of Nigeria, Benin Republic, Togo, and Burkina Faso extra early maturing, small seeded cowpea varieties with semi-wild characteristics are grown at the onset of rains and harvested within 50-60 days before insect pressure becomes heavy. These varieties have small smooth seeds with various colour such as black, red, brown, mottled and the 100 seed weight ranges from 4-10g. These have very little market appeal and are mostly used for home consumption. In Nigeria, these varieties are called "Achishiru" (meaning "eat and keep quiet") and are extensively grown between Jos and Kaduna with Kafanchan as the centre. These "Achishiru" cowpea are planted in April-May with the onset of rains and harvested in July. Being small seeded and early maturing, pods develop very quickly and become fibrous which makes them less attractive to *Maruca* larvae. Thus, they escape insect damage. In addition, *Maruca* pressure is less during that time.

A large number of field samples of 'Achishiru' cowpea were collected from 1988 to 1991 and tested for field resistance at Kano. When planted at the normal time, most of these were as susceptible as other varieties and had to be sprayed to produce seeds. However, the lines IT88DM-345 and IT89KD-445 were earliest of all and have consistently escaped insects at Kano (**Table 18**). IT91K-180 was evaluated in 1992. This may even have some level of resistance to thrips, *Maruca* and PSB. Seeds have been given to the PHMD Entomologist for testing. In the meantime, these three lines have been crossed with several large seeded improved breeding lines and segregating

populations are being screened to select very early maturing large seeded lines without insecticide protection.

It is expected that with a combination of the above three approaches, it would be possible to create cowpea genotypes which will produce reasonable grain yield both in pure crop and intercrop without any insecticide protection.

### 5.3 Bacterial and fungal diseases

There are several important diseases in the savanna but their incidence and severity vary with latitude which is related to rainfall pattern. Thus, *Septoria*, scab, brown blotch bacterial blight and *Cercospora* are more important in the Guinea Savanna; bacterial blight, *Protomyces* (black spot), *Cercospora* and *Macrophomina* (ashy-stem blight) are important in the Sudan Savanna whereas bacterial blight and ashy-stem blight are important in the Sahel. Most of advanced breeding lines are resistant to brown blotch and *Cercospora*. Therefore, major efforts are being made to combine resistance to relevant diseases for different ecologies.

A number of breeding lines have been identified which are immune or have high levels of resistance to these diseases. Some of the promising lines are listed in **Table 19**. These have been crossed to several improved breeding lines and F<sub>2</sub>, F<sub>3</sub> populations are being screened.

In 1992, an additional 1600 germplasm lines were screened at Samaru, as a joint project with GRU and the PHMD Pathologist, for resistance to *Septoria* and scab. Over 100 lines were found to be resistant. These will be tested again at Samaru in replicated plots to confirm further their resistance before they are used in the breeding program.

### 5.4 Viruses

Cowpea aphid borne mosaic is a severe a problem throughout savanna ecologies and different strains are prevalent. Therefore, concerted efforts underway made in collaboration with the PHMD virologists to develop cowpea varieties resistant to different viruses. All the advanced breeding lines are routinely screened by artificial inoculation each year. Some of the promising lines are listed in **Table 20** and of these, IT90K-59 combines resistance to aphid, bruchid, thrips, *Striga* and *Alectra*. A number of these lines are being used in the breeding program. Tvu 401 to be resistant to several viruses and therefore this line was crossed with several improved breeding lines.

## **6. BREEDING FOR RESISTANCE TO *STRIGA* AND *ALECTRA***

### **6.1 Background**

Two parasitic weeds, *Striga gesnerioides* (Wild.) Vatke, and *Alectra vogelii* (Benth.) of the family Scrophulaceae cause considerable damage to cowpea in the semi-arid regions of Africa. Presently *Striga* is more prevalent in Sudano-Sahelian belt and *Alectra* is more serious in the Guinea Savanna, but both are rapidly spreading beyond these limits. *Striga* incidence has been noticed in the coastal savanna of Benin Republic and *Alectra* is becoming a serious threat in several East and Southern African countries particularly Kenya, Zambia, Zimbabwe and Botswana. Total yield loss is observed in heavily infested fields. These parasites are difficult to control by chemical and/or cultural methods due to the large amount of seeds which they produce and their adaptation/dormancy mechanisms which permit seeds to stay alive in the soil for several years. Therefore, a major component of a long lasting control package for these parasitic weeds should be genetic control through host plant resistance. Initial screening for *Striga* resistance was done by IITA scientists based at Kamboinse, Burkina Faso in 1981 where a total of 54 cowpea lines were planted in a heavily infested field. Subsequently a pot culture technique was developed for *Striga* and *Alectra* and used for controlled studies. A combination of field and pot culture screening has led to identification of several resistant sources and also permitted genetic studies leading towards identification of the genes responsible for resistance to *Striga* and *Alectra* and the allelic relationship among different genes.

### **6.2 Screening procedures**

#### **6.2.1 Field/screening**

Most of the experimental fields at IITA Kano Station are infested with *Striga* and *Alectra*. One of these fields (0.5 ha) was selected and developed as the *Striga* sick plot by evenly spreading 20 bags of matured *Striga* plants and 10 bags of matured *Alectra* plants in it and incorporating them in the soil by repeated harrowing about 3 weeks before planting. This is used for field screening. More inoculum is added each year. In addition, plots at Kano Airport are heavily infested with *Striga* and *Alectra* and these are also used for field screening. Sick plots have also been developed/identified in Burkina Faso, Niger Republic, Nigeria and Benin Republic in collaboration with the

national programs. The test lines are planted in these plots along with known susceptible varieties and data on number of emerged *Striga/Alectra* plants are taken, beginning 5-6 weeks after planting. The days taken to first emergence of *Striga/Alectra* in each line is recorded and then weekly counts are made to study the pattern of *Striga/Alectra* emergence. Seed of lines free from the parasitic weeds and those showing delayed and less emergence in the field are further tested using a pot culture technique in the greenhouse.

### 6.2.2 Pot culture screening

Plastic pots of 13cm diameter and 13cm depth are used for screening. Each pot contains about 1 litre of unsterilized sieved sand and top soil (sandy loam) mixture (1:1 v/v) previously inoculated uniformly with about 800 seeds of *Striga* or *Alectra*. The pots are kept on benches in a greenhouse and planted with test cowpea populations with two plants per pot. The pots are watered daily and weeds other *Striga* and *Alectra* are removed. Emergence of *Striga* and *Alectra* plants in pots containing susceptible plants normally begins from 6 weeks after planting. The experiments are terminated 10 weeks after planting when the differences between resistant and susceptible plants become quite marked. The levels of *Striga* and *Alectra* infection are determined by observing the attachments of *Striga* and/or *Alectra* on the roots of each cowpea plant. The soil is washed off the plant roots after submerging each pot in a 20l bucket of water for about 5 minutes. The roots of each plant are gently separated from the other and the numbers of *Striga* and/or *Alectra* attached to each plant is counted. Plants permitting attachment and healthy development of these parasitic weeds are classified as susceptible and those free of infection or showing only minute *Striga/Alectra* plants are grouped as resistant.

### 6.3 Sources of resistance

The initial lead on cowpea *Striga* resistance came from the work done by the IITA scientists based at Kamboinse, Burkina Faso working under the IITA/IDRC/Burkina Faso and IITA/SAFGRAD (Semi-Arid Food Grain and Development, Organisation of African Unity) projects. Field screening of 54 cowpea varieties at Kamboinse in 1981 indicated two that varieties, 'Gorom Local' from Burkina Faso and '58-57' from Senegal were resistant to *Striga*. These two varieties showed little or no *Striga* emergence compared with a large number of emerged *Striga* on other varieties. These resistant varieties along with other breeding lines were then evaluated by the IITA/SAFGRAD project at

many locations in Burkina Faso, Mali, Republic of Niger, Cameroon and Nigeria during the years 1983-86 to ascertain the stability of *Striga* resistance across the West African savanna. 'Gorom local' and '58-57' showed a high level of resistance to *Striga* only in Burkina Faso. The susceptibility in other countries indicated the presence of different strains. Therefore, the search for additional sources of resistance continued and two new resistant sources, B 301 and IT82D-849, were identified in 1987 through collaborative work of IITA/SAFGRAD Project with Long Ashton Research Station, UK and various national programs. They showed stable resistance to *Striga* across Burkina Faso, Mali, Republic of Niger and Nigeria. B 301, a local germplasm line from Botswana was initially identified to be resistant to *Alectra* in Botswana. In addition to these two lines, a number of lines have also been identified which have lower numbers of *Striga* as well as showing delayed emergence of *Striga*. Some of these lines are listed in **Table 21**. IT86D-534, IT86D-371 and IT84D-666 are moderately resistant to *Striga* and highly resistant to *Alectra* whereas B 301 is completely resistant to both. IT82D-849 is completely resistant to *Striga* but susceptible to *Alectra*. Suvita-2, which is resistant to *Striga* in Burkina Faso, is moderately susceptible to *Striga* in Nigeria and highly susceptible to *Alectra*. Among the lines highly susceptible to *Striga*, some are also susceptible to *Alectra*. These data (**Table 21**) show the scale of yield loss due to parasitic weeds and demonstrate that breeding for *Striga* resistance alone in cowpea is not enough. *Alectra* can also cause damage as is evident in the yield performance of IT82D-849 and Suvita-2. Therefore, resistance to both parasitic weeds must be incorporated in improved varieties.

#### **6.4 Mechanism and genetics resistance in different cowpea varieties**

##### **6.4.1 Manifestation of resistance**

Field and pot culture studies have revealed major differences in the expression of resistance in different varieties. Lack of emergence or delayed and less emergence are noticed in resistant and moderately resistant lines compared to severe infestation of susceptible lines. In the pot culture test of B 301, at the two and four week root washings, we observed that this line stimulates germination of *Striga* as well as *Alectra* seeds and permits attachment. However, haustorial formation and further growth are inhibited and the parasite primordia subsequently die and disintegrate so that B 301 roots look apparently free of infection. This indicates a hypersensitive type reaction. The expression of resistance to *Striga* in IT82D-849 is a bit different from B 301.

This line also stimulates *Striga* seed germination and attachment and inhibits haustorial development like B 301. However about 10% of the plants show some haustorial development and support limited *Striga* growth with occasional emergence of one or two *Striga* plants which are very weak and die before reproductive maturity. Unlike B 301, IT82D-849 is highly susceptible to *Alectra* permitting normal attachment and growth of *Alectra* plants. The variety IT81D-994 is moderately resistant to *Striga* and *Alectra*. It permits establishment of a few *Striga* and *Alectra* (3-5/plant) but delays their emergence. Any *Alectra* that emerge are weak and seldom reach maturity. In contrast the few emerged *Striga* plants reach maturity but cause little damage to the plants. The reactions of Suvita-2 to *Striga* from Burkina Faso and *Alectra* are similar to that of IT82D-849, but it is susceptible to the *Striga* strain from Nigeria.

#### 6.4.2 Genetics of resistance

Good progress has been made in elucidating the genetics of resistance to *Striga* and *Alectra* in cowpea. Systematic genetic studies have revealed single dominant gene for *Striga* and duplicate dominant genes for *Alectra* resistance in B 301. Further studies have showed that resistance in IT82D-849 to *Striga* is also controlled by a single dominant gene but it is different from that in B 301. Also, the single dominant gene possessed by Suvita-2 against the *Striga* strain from Burkina Faso is non-allelic to the single dominant genes in B 301 and IT82D-849. The dominant duplicate genes in B 301 against *Alectra* are non-allelic to a single gene in IT81D-994. Screening the parents of IT82D-849 and an allelic test revealed that its source of *Striga* resistance is from Emma 60. Gene symbols Rsg<sub>1</sub>, Rsg<sub>2</sub> and Rsg<sub>3</sub> are proposed for resistance to *Striga gesnerioides* in B 301, IT82D-849 and Suvita-2 respectively and gene symbols Rav<sub>1</sub>, Rav<sub>2</sub> and Rav<sub>3</sub> are proposed for resistance to *Alectra vogelii* in B 301 and IT81D-994. Most of these data have already been published.

#### 6.4.3 Resistance mechanisms

Two factors play important role in the response of cowpea to infection by parasitic weeds:

- (1) Production of active stimulant
- (2) The defense mechanism of the host plant

In the situation where both factors act simultaneously, the resultant effect is the hypersensitive reaction leading to germination but death of the parasite as shown by B 301. It is proposed that the balance

between stimulant production and defense mechanism changes due to different genotypes of the host plant, thus resulting in the threshold effects exhibited by IT82D-849, Emma 60 and SUVITA-2. IT81D-994 permits a lesser number of *Striga* plants to attach and develop thus showing a moderate level of resistance. The emerged *Alectra* plants on IT81D-994 are slow growing and rarely reach maturity. On the other hand, if the host plant produces an active stimulant but does not have a good defence mechanism, it gets attacked as in IT84S-2246-4. The mechanisms of resistance shown by these resistant cowpea lines have the potential of reducing the number of parasite seeds in the soil over time.

### 6.5 Development of resistant varieties

A systematic breeding program for resistance to *Striga* and *Alectra* using B 301 as resistant source began in 1987. This is a land race from Botswana which has very small seeds and prostrate growth habit with late maturity. It is, therefore, an unacceptable variety for West Africa. This resistant line was crossed to a susceptible variety, IT84S-2246-4 which is otherwise a high yield variety with resistance to aphid, bruchid, thrips, and several diseases. The F1 was backcrossed to IT84S-2246-4 and the resistant BC1 F1 plants were grown in the greenhouse to maturity in 1988. The BC1 F2 families were planted at Ibadan in the off season and a large number of agronomically desirable plants were selected at maturity and threshed individually. The selected BC1 F3 progenies were then screened for resistance in 1989 at Kano in a field heavily infested with *Striga* and *Alectra*. Individual plants were selected based on resistance as well as on agronomic characters and the selected BC1 F4 plant progenies were then multiplied at Ibadan in the off season. Individual F4 plants were selected based on agronomic characters. The selected BC1 F5 progenies were then screened in 1990 at Kano in the field as well as at Samaru in pot culture. The remanent seeds of selected F4 and F5 lines were tested for resistance to aphids and bruchids. A number of F6 breeding lines were then selected which were very similar to IT84S-2246-4 and had combined resistance to aphid, bruchid, thrips, *Striga* and *Alectra* and several diseases. These have been evaluated for yield and other characters in replicated trials in the 1991 and 1992 crop seasons and have done well (Table 22). The *Striga* resistant breeding lines are much superior in yield compared to IT84S-2246-4 which was used as a genetic base for improvement. These lines have been distributed to various national programs in Africa. These same lines

are used as parents in the crossing program involving local varieties and other selected parents in order to develop a range of varieties including local varieties differing in plant type, maturity and seed characteristic to suit different cropping systems and regional preferences.

## 6.6 New sources of resistance

In view of the fact that strain diversity exists in *Striga*, it is desirable to have genetically diverse sources of resistance so that stable resistance can be bred in new improved cowpea varieties. Therefore, 1600 cowpea germplasm lines were screened in 1992 in the field at IITA Kano station. Each line was planted in *Striga* sick plot in 3m long rows which were 1.5m apart. Two plants per hill were maintained within the rows with a hill to hill distance of 20cm. The days taken to first *Striga* emergence and the number of emerged *Striga* per plot was recorded each week started 5 weeks after planting. At maturity 104 lines remained free from *Striga*. These lines were further tested in the screenhouse using the pot culture technique and 17 lines were found to have high levels of resistance to *Striga*. Some of these were also resistant to *Alectra* (Table 23). Interestingly, all sources of *Striga* and *Alectra* identified to date originated from germplasm lines from East and Southern Africa. These are being crossed to B 301, and IT82D-849 to ascertain whether they have the same or different genes for resistance.

## 6.7 Emergence of a new *Striga* strain in Benin Republic

In 1990, a few plants of IT82D-849 and B 301 were found susceptible at Zakpota, Republic of Benin. Systematic studies were then undertaken to elucidate whether this was due to seed mixture or existence of a new strain. A number of known susceptible and resistant lines to cowpea *Striga* were evaluated in 1991 and 1992 at and around Zakpota and data on *Striga* infestation was collected. The data on *Striga* emergence are presented in Table 24. The results suggest some level of susceptibility in B 301 as well as in IT82D-849 which indicated the presence of a new strain at Zakpota. It was good to observe that IT81D-994, which is moderately resistant to *Striga* and *Alectra* in Nigeria is completely resistant to the new strain at Zakpota. Thus, it should be possible to develop cowpea varieties resistant to all known strains of *Striga* by crossing B 301 derived lines and IT81D-994. This work is already in progress.

## 6.8 Long term experiment on *Striga* control

An experiment was initiated in 1990 at Kano Airport involving B 301, IT82D-849, TVx 3236 (pure crop stand), TVx 3236 Intercropped with millet, IT86D-472 and fallow treatments to study their long term effect on the *Striga* population. Each plot consists of 20m x 15m with two replications. Each variety is a treatment and is planted on the plot each year with two 2m x 3m windows of the susceptible variety, TVx 3236 randomly located to estimate the level of *Striga* concentration in the plot. The data collected so far suggest that a reduction of the *Striga* population has occurred in all the plots compared with the fallow plot (Table 25), with more reduction occurring in the plots of B 301 and IT82D-849. This experiment will continue for two more years.

## 7. PYRAMIDING GENES FOR PEST AND DISEASE RESISTANCE

In view of the fact that cowpea is attacked by several diseases, insects and parasitic weeds, the improved varieties must have resistance to all these if possible. As indicated in previous sections, good sources of resistance are available for important diseases like *Septoria*, scab, brown blotch, bacterial blight, blackspot, *Cercospora* and insects such as aphid, bruchid, and thrips as well as the parasitic weeds, *Striga* and *Alectra*. Systematic efforts are underway to combine all these resistances into a range of plant type, maturity groups and seed types both in photosensitive and non-photosensitive genetic backgrounds. The main strategy is to select parents which have desirable sets of genes, cross them and use the desired populations for recurrent selection and crossing so that in each cycle a few genes are added. An example is given in Figs. 3 and 4. IT84S-2246-4 was developed through systematic crossing and selection and possesses resistance to several diseases and insect pests (Fig. 3). This was crossed with local varieties on one hand and B 301 on the other hand and then the resulting F<sub>6</sub> progenies of the two streams crossed back again to develop a range of plant types combining resistance to diseases, insects and *Striga* (Fig. 4). Recently parents with resistance to bacterial blight, *Septoria*, scab, blackspot and viruses have been included in this stream. With every generation definite progress is being made and it is expected that in the next few years, most of the breeding lines will have resistance to major diseases, aphid, bruchid, thrips, *Striga* and *Alectra*. These will be simultaneously crossed with parents having a low level of resistance to *Maruca* and PSB for further improvement.

## **8. BREEDING FOR DROUGHT TOLERANCE**

### **8.1 Background**

Cowpea suffers considerable damage due to drought in the Sahelian Region. Therefore, a systematic program was initiated in 1988 to screen cowpea varieties for drought tolerance and to develop screening methods. Thirty cowpea varieties were screened for drought tolerance and root characteristics.

### **8.2 Screening for drought tolerance**

Drought tolerance was measured as the number of days taken for permanent wilting after termination of watering of the plants. Test lines were planted in single rows in wooden boxes about 90cm x 60cm x 10cm filled with a mixture of sand and top soil (1:1). Each row contained about 12 plants. The experiment was replicated four times. The plants were watered upto two weeks after planting. When the first trifoliate leaf had emerged, the watering was stopped. Notes on cumulative percent wilting each day after termination of watering were taken for each variety. When most of the lines had wilted, water was applied again to study the recovery percentage for the different lines. Based on the first screening, the experiment was repeated using 12 varieties which represented a range of drought tolerances. The results are presented in **Table 26**. Two varieties, Gorom Local and IT81D-994 appeared to be the most drought tolerant. These lines also showed the best recovery after watering was resumed. Field data and subsequent work has further confirmed the results, (see Annex 1).

### **8.3 Root characteristics**

The same 12 varieties used in the previous study were screened for root characteristics. This was done using polythene pipes which were 1m long and of 15cm diameter. These pipes were filled with a mixture of sand and top soil (1:1) and three seeds of each variety were planted but thinned to one plant after germination. Each variety was replicated four times. Normal watering was done each day. For four weeks after planting the polythene pipes were cut open and submerged in water tanks. The roots were carefully washed out and for subsequent measurements. The results

are presented in **Table 26**. A great deal of variability was noticed among varieties. There was no correlation between drought tolerance and root length. IT81D-994 had long roots and appeared to be drought tolerant whereas IT83S-818 had long roots and was drought susceptible.

These studies demonstrated apparent genetic variability in drought tolerance and root characteristics in cowpea and provide a foundation for further work.

#### **8.4 Dry season planting**

Several countries in the savanna region have developed irrigation facilities where wheat or vegetables are being grown in dry season. Often, wheat planting is delayed for various reasons and the late planted wheat gives very poor yield. Therefore, several improved early maturing cowpea varieties were evaluated at Wudil and Kadawa in 1991 and 1992 by planting in late January to assess whether cowpea will be a good alternative crop in cases where a farmer could not plant wheat in time. The results (**Table 27**) have been encouraging. Varieties like IT84S-2246-4, IT90K-76 and IT90K-59 have yielded between 1.5-1.9MT/ha when harvested in late April, well before the onset of rains **Table 27**. The seed quality is excellent and the produce comes into the market when cowpea prices are very high. This will not only be a profitable alternative to late planted wheat but it would also break up repeated cereal-cereal planting and thus improve the soil.

## 9. INTERACTION WITH NATIONAL AND REGIONAL PROGRAMS

Collaboration with national programs has been considerably strengthened during the last five years. In view of the budget constraints, cowpea improvement work by IITA at the ICRISAT Sahelian Centre was phased out and this is now being accomplished through collaboration with the scientists of the National Institute of Agronomic Research of Niger (INRAN). They manage IITA's preliminary and advanced trials at Kolo, Gabougoura and Maradi and assist in selection of promising lines for the dry regions. Similarly IITA's preliminary and advanced trials are conducted by scientists at IRA, Maroua (Cameroon) and CRI, Nyankpala (Ghana). Efforts are underway to develop similar arrangements with scientists at Ouagadougou and Bamako so that all the agro-ecological zones in West and Central African Savanna and Sahel can be covered. Needed assistance is provided to strengthen these national programs.

IITA's cowpea breeding program works hand in hand with cowpea scientists of Nigeria as an active member of the Nationally Co-ordinated project. We are also receiving considerable assistance from IAR/ABU scientists in breeding for *Striga* resistance. The cowpea breeder from IAR, Samaru, spent two weeks in 1992 at IITA Kano Station to obtain a better insight into IITA's cowpea breeding program.

**Table 28** shows the results of the coordinated cowpea trial jointly planned and conducted in 1992 at various locations in Nigeria. The results of these trials form the basis of variety releases in Nigeria. Through the collaborative work of IITA and Nigerian scientists, three new varieties IT84S-2246-4, IT86D-719 and IT86D-721 were recently released in Nigeria for general cultivation in 1992/93 and two *Striga* resistant varieties IT90K-59 and IT90K-101 have been identified as very promising.

We also have very active links with SAFGRAD and SADC cowpea improvement programs as well as the Bean/Cowpea Co-operative Research Support Program of USAID in Cameroon and Ghana.

The most promising breeding lines selected from preliminary and advanced trials are multiplied and distributed to over 50 countries in the form of cowpea international trials. This has been a very effective program and over 45 countries have tested and released IITA's cowpea varieties (**Table 29**). The demand for these trials is always more than we can supply. Efforts are made to visit national programs and provide on the spot technical

advice and also learn from them about regional/site specific problems. In 1992, principal cowpea scientists from Burkina Faso, Nigeria, Niger Republic, Ghana, Cameroon, Benin Republic, Tanzania, Zambia, Zimbabwe, Mozambique, and Lesotho participated in a grain legume monitoring tour covering Ibadan, Mokwa, Samaru and Kano, followed by a group discussion lasting one full day.

# **TABLES**

**Table 1. Cowpea in the cropping systems of West Africa**

**A. Forest and Southern Guinea Savanna**

1. Cassava-cowpea
2. Maize-cassava-cowpea
3. Maize-cowpea
4. Maize-cowpea, relay or double crop in second rainy season

**B. Northern Guinea Savanna**

5. Groundnut-cowpea
6. Groundnut-sorghum-cowpea with or without millet
7. Sorghum-cowpea

**C. Sudan Savanna**

8. Millet-sorghum-cowpea, relay with or without groundnut.
9. Millet-groundnut-cowpea

**D. Sahelian Zone**

10. Millet-cowpea

Table 2. Yields of component crops in different cropping systems (Minjibir and Gazawa LGA: 1991)

Farmer	Grain Yield kg/ha				Fodder Yield kg/ha			Total kg/ha
	E. Cowpea	Millet	Sorghum	G.Nut	L. Cowpea	Millet	Sorghum	
1.	123	1455	-	-	1643	1300	-	4521
2.	138	-	2150	168	-	-	3270	5726
3.	405*	-	905	-	-	-	7083	8393
4.	128	-	945	-	2963	-	4710	8746
5.	173	-	280	-	-	-	14065	14518
6.	83	1858	-	-	2365	3060	-	7366
7.	60	1563	-	43	1598	3075	-	6339
8.	75	-	1605	38	-	7060	-	8778
9.	160	693	628	-	1365	1602	965	5413
10.	23	750	1318	-	775	1105	5030	9001
11.	-	1363	-	-	1920	4208	-	7491
12.	148	700	105	-	-	2283	830	4066
13.	125	1348	-	-	748	3815	-	6036
14.	85	-	503	270	850	-	643	2351
	110	1216	937	129	1580	3056	4575	

\* Not included in the mean because it was sprayed with insecticide

**Table 3. Sequence and method of testing improved cowpea breeding lines**

Materials	Trial Type	Design	No. of Reprs.	Locations
New Breeding lines	IET	Augumented	1	Gumel, Kano, Samaru
Selection from IET	PVT	RBD	3	Gumel, Kano, Samaru, Ibadan, Maiduguri, Niamey
Selections from PVT	AVT	RBD	4	Gumel, Kano, Samaru, Ibadan, Maiduguri, Niamey, Maradi, Maroua Nyankpala
Selection from AVT	CIT	RBD	4	National collaborators

**Table 4. Number and types of cowpea variety trials conducted in different years**

Types of Trial	Number of trials in different years				
	1988	1989	1990	1991	1992
IET	4	3	3	1	1
PVT	4	10	8	8	4
AVT	6	7	7	9	10

**Table 5. Performance of most promising cowpea breeding lines evaluated in different advanced variety trials 1988 (monocrop with insecticide sprays)**

Variety	Grain Yield kg/ha					Reaction to*			
	IITAF	IITAS	Mokwa	Samaru	Kano	BB	Aphids	Bruchid	Thrips
<b>Advanced Trial-1 (White-early)</b>									
IT87S-1475	1608	2228	1793	637	968	R	S	S	R
IT86D-718	2021	1794	1799	866	491	R	S	S	R
IT86D-719	2169	1811	1659	639	705	R	MR	S	R
IT84S-2246-4(check)	1646	2081	1798	689	1086	S	R	R	R
LSD-5%	543	848	421	232	409				
<b>Advanced Trial-2 (White-medium)</b>									
IT85D-3517-2	1562	1224	196	626	1273	R	S	S	R
IT86D-715	1133	855	2607	939	1315	R	S	S	R
IT86D-957	1112	861	1874	637	1587	R	S	S	R
IT82D-699 (check)	952	675	1735	564	543	R	S	S	R
LSD-5%	456	556	595	301	339				
<b>Advanced Trial-3 (Brown-early)</b>									
IT87S-1304	1670	1865	2091	1315	731	R	S	S	R
IT86D-792	1797	2499	1710	741	491	MR	R	R	R
IT84S-2246-4 (check)	2109	1763	2043	1023	1200	S	R	R	R
LSD-5%	526	826	352	322	356				
<b>Advanced Trial-4 (Brown smooth-early)</b>									
IT86D-633	1116	1236	2295	1200	1545	S	S	S	R
IT86D-472	776	1457	2136	511	2119	S	R	S	R
IT86D-534	962	1261	1924	898	1900	S	R	R	R
VITA-7 (check)	1397	736	1954	1106	1030	R	S	S	S
LSD-5%	382	645	580	346	445				
<b>Advanced Trial-5 (Brown medium)</b>									
IT85F-2246	1179	1654	2283	1200	1472	R	S	S	R
IT86D-627	1025	1248	3013	981	887	R	S	S	R
IAR-48 (check)	1172	1286	2522	595	741	S	S	S	MR
LSD-5%	440	586	386	265	470				

F = First season (May-July) S = Second season (Aug - Oct)

\*BB = Bacterial Blight R = Resistant MR = Moderately Resistant S = Susceptible

**Table 6. Performance of most promising breeding lines evaluated in different advanced trials in 1989 (monocrop with insecticide sprays)**

Variety	Grain Yield kg/ha		Reactions to*			
	Kano	Samaru	BB	Aphid	Bruchid	Thrips
<u>Advanced Trial-1 (White early)</u>						
IT86D-721	1534	1503	MR	S	S	R
IT87D-829-5	1241	2547	R	S	S	R
IT86D-719	1187	1962	R	MR	S	R
Kano Early (Check)	587	407				
LSD-5%	437	358				
<u>Advanced Trial-2 (White medium)</u>						
IT87D-661	2287	1732	S	S	S	R
IT86D-715	2237	2464	R	S	S	R
IT86D-975	2086	2150	R	S	S	R
Kano Early (check)	326	400	R	S	S	S
LSD-5%	707	488				
<u>Advanced Trial-3 (Brown early)</u>						
IT87D-939-1	765	1587	R	S	S	R
IT87D-298	697	1419	MR	R	R	R
IT84S-2246-4 (check)	750	1524	S	R	R	R
LSD-5%	284	649				
<u>Advanced Trial-4 (Brown smooth early)</u>						
IT86D-400	1291	2338	MR	R	R	R
IT86D-486	1216	1962	MR	R	R	R
IT86D-477	1165	1941	MR	R	R	R
IT84E-124 (check)	1148	1294	S	S	S	R
LSD-5%	560	590				
<u>Advanced Trial-5 (Brown medium)</u>						
IT85F-2264	1248	2486	R	S	S	R
IT87S-1357	1517	1795	S	R	S	R
IT87D-1891	1396	2088	S	R	S	R
IT87D-697-2	1254	2651	R	R	R	R
IAR-48 (check)	408	2004	R	R	R	R
LSD-5%	464	549	S	S	S	MR

\*BB = Bacterial Blight R = Resistant MR = Moderately Resistant S = Susceptible

Table 7. Performance of most promising breeding lines evaluated in different advanced trials in 1990 (monocrop with Insecticide sprays)

Variety	Grain Yield kg/ha			Reactions to*			
	Kano	Samaru	Gumel	BB	Aphid	Bruchid	Thrips
<u>Advanced Trial - 1 (White and brown early)</u>							
IT87D-879-1	1191	2216	947	R	R	S	R
IT87D-885	1177	1529	1064	R	S	R	R
IT87D-298	1668	1263	547	MR	R	R	R
Kano early (check)	856	207	529	R	S	S	S
<u>Advanced Trial - 2 (White and brown medium)</u>							
IT87D-697-2	1251	1343	744	R	R	R	R
IT86D-715	1025	1687	515	R	S	S	R
IT87D-1629	1075	1573	534	R	S	S	R
TVx 3236	590	1505	281	R	S	S	R
LSD - 5%	399	359	203				
<u>Advanced Trial - 3 (Medium spreading)</u>							
IT87D-2075	1430	903	876	R	S	S	R
IT88DM-361	1385	1460	720	R	S	S	R
IT88DM-363	1363	974	536	R	S	S	R
Kano late (check)	492	453	226	R	S	S	S
LSD - 5 %	406	654	287	R	S	S	S
<u>Advanced Trial - 4 (Medium smooth)</u>							
IT88S-496-5	661	1503	1462	S	R	R	R
IT88S-715	616	1575	898	R	R	S	R
IT87D-611-3	521	1204	376	R	R	S	R
TVx 1948-01F (check)	344	860	507	R	S	S	S
LSD - 5%	406	472	573				
<u>Advanced Trial - 5 (Photosensitive early)</u>							
IT88DM-400	499	229	337	R	S	S	R
IT89KD-245	477	195	328	MR	R	R	R
Kano Late (check)	277	322	347	R	S	S	S
LSD - 5%	197	203	153				

\* BB = Bacterial blight    R = Resistant    MR = Moderately Resistant    S = Susceptible

**Table 8. Performance of most promising breeding lines evaluated in different advanced trials in 1991 (monocrop with insecticide sprays)**

Variety	Grain Yield kg/ha						Reactions to*			
	Kano	Samaru	Gumel	Maroua	Niamey	Maiduguri	BB	Aphid	Bruchid	Thrips
<u>Advanced Trial - 1 (Early maturing)</u>										
IT89KD-792	1225	1042	390	1309	882	-	MR	R	R	R
IT89KD-374-57	915	624	702	1650	1011	-	R	R	S	R
Dan Ila	514	533	518	1279	786	-	R	S	S	S
IT84S-2246-4(check)	961	688	124	746	356	-	S	R	R	R
LSD - 5%	437	308	215	418	590					
<u>Advanced Trial - 2 (Medium maturing)</u>										
IT89KD-374-57	1692	779	806	2261	720	-	R	R	S	R
IT88D-867-11	1293	862	829	1306	740	-	R	R	S	R
IT88DM-363	1502	1096	476	2339	595	-	R	S	S	R
IAR-48 (check)	1697	823	432	2100	330	-	S	S	S	MR
LSD-5%	496	319	232	518	374					
<u>Advanced Trial-3 (Photosensitive early)</u>										
IT88DM-400	693	825	820	839	474	634	R	S	S	R
IT89KD-337	999	819	1009	1044	208	625	R	S	R	S
Dan Ila (check)	754	710	1119	1364	731	528	R	S	S	S
LSD-5%	478	296	359	465	428	411				
<u>Advanced Trial-4 (Photosensitive late)</u>										
IT89KD-245	1535	835	887	419	81	149	MR	R	R	R
IT89KD-260	1219	791	1161	622	133	193	R	R	R	R
Kananado (check)	708	1215	246	31	0	0	S	S	R	S
LSD-5%	546	308	539	237	245					

\*BB = Bacterial Blight, R = Resistant, MR = Moderately Resistant, S = Susceptible

Table 9. Performance of most promising breeding lines evaluated in advanced trials in 1992 (monocrop with insecticide sprays)

Variety	Grain Yield kg/ha						Reactions to*			
	Kano	Samaru	Gumel	Maiduguri	Maradi	Nlamey	BB	Aphid	Bruchid	Thrips
<u>Advanced Trial-1 (Early maturing)</u>										
IT91KD-45	1493	773	1033	550	-	-	R	R	R	R
IT90K-59*	1190	936	1108	7	-	-	R	R	R	R
IT90K-284-2	904	1004	991	469	-	-	R	R	S	S
IT88D-643-1	725	358	1422	606	-	-	R	R	S	S
IT84S-2246-4 (check)	499	250	83	61	-	-	S	R	R	R
LSD-5%	286	438	324	328						
<u>Advanced Trial-2 (Medium maturing)</u>										
IT90K-277-2	1537	375	952	1058	-	-	R	R	R	R
IT89KD-374-57	808	810	1511	1018	-	-	R	R	S	R
IAR-48 (check)	1395	553	406	519	-	-	S	S	S	S
LSD-5%	408	465	374	365						
<u>Advanced Trial-3 (Medium spreading)</u>										
IT88D-367-11	636	187	805	428	1347	755	R	R	S	R
IT89KD-347-57	993	431	1067	403	1264	630	R	R	S	R
IT90K-319	1458	470	401	509	1123	266	R	R	R	R
Dan Ilan (check)	1096	313	906	460	1012	255	R	S	S	S
LSD - 5%	367	233	308	198	317	225				
<u>Advanced Trial-4 (Photosensitive late)</u>										
IT89KD-288	1081	427	-	659	-	-	S	R	R	R
IT89-256	506	232	-	941	-	-	R	R	R	R
Kananado (check)	357	132	-	462	-	-	S	S	R	S
LSD - 5%	301	332		420						

\* Also resistant to *Striga*

**Table 10. Variety performance in advanced trials from 1988 to 1992 (abstracted from Tables 5-9), monocrop with insecticide sprays**

Year	Grain Yield kg/ha		
	Samaru	Kano	Gumel
A. Early maturity check: IT84S-2246-4			
1988	689	1086	-
	1023	1200	-
1989	1524	750	-
1990	-	-	-
1991	688	961	124
1992	250	499	83
B. Medium maturity (IAR-48)			
1988	595	741	-
1989	2004	408	-
1990	-	-	-
1991	823	1697	432
1992	553	1395	406

**Table 11. Mean performance of millet and cowpea varieties (grain yield, kg/ha) in different trials grown as intercrop without insecticides at Kano 1991**

Trials	Yield of cowpea (kg/ha)				Yield of millet (kg/ha)	
	Grain		Fodder		Stalk	Grain yield
	Mean	Range	Mean	Range		
Advance 1	89	13-216	992	281-1563	2500	487
Advance 2	116	6-248	1493	625-2500	3944	1003
Advance 3	162	23-448	199	177-214	3236	626
Advance 4	80	22-264	784	81-2000	2500	386
Advance 5	88	20-213	807	281-1469	4395	885
Advance 6	45	12-100	531	125-1500	3860	680
Advance 7	61	15-162	380	62-1188	3721	585
Advance 8	39	5-68	535	125-1563	2638	578
Advance 9	78	10-155	1360	625-3062	3375	788
Prelim 1	78	41-143	1016	250-1625	3055	489
Checks:						
Dan Ila	80	26-134	808	200-1437		
Kananado	71	-	2000	-		
IAR 1696	69	-	1312	-		
LSD 5%					381	998

**Table 12. Performance of most promising cowpea varieties intercropped with millet in different trials at Minjibir 1991 without insecticide spray**

Trial	Mean grain yield (kg/ha) of top 3 varieties						Trial Mean	SE
	V1	Yield	V2	Yield	V3	Yield		
Advance 1	89KD-381	216	89KD-792	169	89KD-457	153	89	35
Advance 2	89KD-451	248	89KD-391	224	88DM-363	224	115	41
Advance 3	88DM-400	448	89KD-444	279	87KD-2075	246	162	54
Advance 4	89KD-107-5	263	89KD-353	155	89KD-260	134	80	42
Advance 5	89KD-355	213	88DM-400	192	84D-666	182	88	31
Advance 6	88S-496-5	100	89KD-43-3	75	89KD-76-6	67	45	18
Advance 7	89KD-107	162	90K-(APL-1)	136	90K-59	134	61	33
Advance 8	88D-584-1	75	86D-1056	71	89KD-260	68	39	21
Advance 9	87D-697-2	155	89KD-374	145	88DM-345	121	77	32
Prelim 1	89KD-307	144	90K-59-3	133	90K-300-9	104	78	30
Check	Dan Ila	114	Dan Ila	26	Dan Ila	134	80	-
Across all trials mean	All vars	194	All vars	145	All vars	140	83	

Table 13. Performance of improved cowpea varieties without spray in Pure and Intercrop culture, 1992

Variety	Minjibir		Wudil		Gumel		Maroua		Reaction to*			
	Pure	InterCp	Pure	InterCp	Pure	InterCp	Pure	InterCp	BB	Aphid	Bruchid	Thrip
IT89KD-374-57	319	228	73	27	334	42	688	225	R	R	S	R
IT88D-867-11	216	95	16	32	250	22	19	28	R	R	S	R
IT89K-107-5	186	233	0	25	87	23	256	53	R	R	R	R
IT90K-319	54	147	0	25	367	9	44	106	R	R	R	R
Dan Ila	73	58	9	7	164	1	175	69	R	S	S	S
IT90K-59**	639	261	81	476	264	27	6	63	R	R	R	R
IT88DM-400	0	198	0	62	92	5	506	166	R	S	S	R
IT89KD-391	87	169	0	13	263	1	38	38	R	R	R	R
IT89KD-355	457	242	19	44	326	15	75	41	R	R	R	R
IT88DM-363	46	97	9	32	58	10	544	556	R	S	S	R
IT90K-261-3	269	269	35	134	160	36	56	22	R	R	R	R
IT89KD-457	180	179	167	171	-	-	-	-	R	R	R	R
LSD-5%		187		114								

\*BB = Bacterial Blight, R = Resistant, MR = Moderately Resistant, S = Susceptible

\*\*Also resistant to *Striga*

**Table 14. Grain yield (kg/ha) of improved cowpea varieties on farmers fields 1992**

Variety	Farmers*					Resistance to:			
	1	2	3	4	Mean	<sup>1</sup> BB	Aphid	Bruchid	Thrips
IT89KD-374	53	148	474	38	178	R	R	S	R
IT89KD-374-57	37	95	205	144	120	R	R	S	R
IT89KD-319	181	50	65	90	102	R	R	R	R
Dan Ila	43	12	85	201	64	R	S	S	S
IT88D-867-11	68	54	7	122	62	R	R	S	R
IT88DM-400	54	67	13	81	54	R	S	S	R
IT89KD-107-S	18	2	105	59	46	R	R	R	R
IT89KD-245	42	70	18	42	44	MR	R	R	R
IT90K-59	43	8	43	76	42	R	R	R	R
Mean	60	56	112	94	79				

<sup>1</sup>Bacterial Blight

\*Each farmer had only one variety thus, farmer ≠1 is not a replication (see text Section 4.2.1)

**Table 15. Grain and fodder yield of dual purpose cowpea varieties evaluated at Kano 1990 (insecticide used, monocrop)**

Variety	Yield kg/ha		
	Grain	Fresh Fodder	Dry Fodder
IT89KD-275	1306	4773	1443
IT88D-249-3	1120	7548	2442
IT89KD-260	955	3330	1199
IT89KD-245	761	6105	1776
IT89KD-355	977	3552	1110
IT89KD-288	847	4773	1332
Kananado	254	2220	610
LSD-5%	699		1260

**Table 16. Performance (kg/ha) of improved cowpea varieties in different cropping systems, 1992 with insecticide, grown in a demonstration at Kano**

Variety	Pure	Cowpea		Millet		Growth Habit
	Stand Cowpea	Strip	Inter	Strip	Inter	
IT90K-284-2	2010	921	441	559	2345	Early erect
IT87D-941-1	1468	867	523	605	1697	Early erect
IT90K-59	1508	600	523	829	1654	Early semi-determinate
IT86D-719	1533	670	433	595	941	Medium semi-determinate
IT86D-715	1312	833	302	814	2081	Medium semi-determinate
IT89KD-349	979	916	310	852	1865	Medium spreading, photosensitive
Dan Ila	493	511	205	753	1947	Medium spreading, photosensitive
IT89KD-355	550	624	596	805	1593	Medium spreading, photosensitive

**Table 17. Promising breeding lines with resistance to different insect pests**

Breeding Lines	Reaction to		
	Aphid	Thrips	Bruchid
IT84S-2246-4	R	MR	R
IT86D-534	R	MR	R
IT88D-867-11	R	MR	S
IT89KD-374-57	R	MR	S
IT89KD-775	R	MR	R
IT90K-101	R	MR	R
IT90K-81-4	R	MR	R
IT90K-59*	R	MR	R
IT90K-76*	R	MR	R
IT90K-77*	R	MR	R
IT90K-361-3	R	MR	R
IT90K-277-2	R	MR	R
IT90K-284-2	R	MR	R
IT89KD-245	R	MR	R
IT89KD-260	R	MR	R
IT89KD-288	R	MR	R
IT89KD-256	R	MR	R

\*Also resistant to *Striga*.

**Table 18. Range in grain yield (kg/ha) of cowpea varieties grown as pure crop without insecticide sprays**

Year	Trial	Range*	Best Varieties
1989	Ad -1	0-995	IT84S-1463, IT86D-721, IT86D-719
	Ad -2	0-856	IT86D-715, IT86D-714, IT86D-957
	Ad -3	0-891	IT87F-491, IT87D-415, IT84S-2246-4
	Ad -4	0-783	IT87S-1357, IT87D-1134, IT85F-2264
	Ad -5	0-438	IT84E-124, IT86D-534, IT86D-486
	Ad -6	0-383	IT86D-633, IT86D-551, IT87D-569
1990	Ad 1-5	0-<50	Several and prolonged attacks of <i>Maruca</i>
	Ad- 6	0-530	IT89KD-455, IT88DM-345
1991	Ad -1	35-651	IT89KD-457, IT89KD-386, IT90K-59
	Ad-2	0-254	IT88DM-363, IT86D-715, IT89KD-374-57
	Ad-3	0-525	IT89KD-95-13, IT89KD-355, IT89KD-389
	Ad-4	0-465	IT89KD-353, IT89KD-260, IT89KD-374
	Ad-5	0-917	IT89KD-455, IT89KD-345, IT89KD-355
	Ad-6	0-570	IT88S-715, IT89KD-455, IT86D-534
1992	Ad-5		
	Kano	0-639	IT90K-59, IT89KD-355, IT89KD-374-57
	Wudil	0-167	IT89KD-457, IT90K-59, IT89KD-374-57
	Gumel	58-367	IT90K-319, IT89K-374-57, IT89KD-355
	Maroua	6-688	IT89KD-374-57, IT88DM-400, IT88DM-363

\* Each trial had 20 varieties

\*\* For disease and insect reaction of best lines from these, see Table 13

**Table 19. Cowpea breeding lines resistant to different diseases**

Diseases	Resistant Lines
Brown Blotch	IT82E-16, IT82//d-699, IT86D-719, IT86D-715, IT84S-2246-4
<i>Septoria</i>	IT86D-1056, IT88S-501-8, IT81D-994, IT90K-82-2, IT90K-81-4, IT85D-3577, IT86D-885, IT90K-284-2
Scab	IT86D-1056, IT88S-501-8, IT90K-81-4, TVx 3236, IT84S-2246-4, IT90K-59, IT90K-76,
Bacterial blight and <i>Cercospora</i>	IT90K-284-2, IT90K-277-2, IT86D-719, IT85D-3517-2, IT89KD 374-57, IT89KD-391, IT89KD-109, IT88D-867-11, IT86D-782, IT81D-1228-14
Black spot	IT87D-590-5, IAR-48, IT88S-524-7, IT84D-666
Ashy-stem blight	Screening in progress

**Table 20. Cowpea breeding lines resistant to different viruses (results from IITA-Virologist)**

Breeding line	Reaction to different virus strains						
	CAMV (Onne)	CAMV IT-16	CAMV 81-11	CAMV K 5-9-90-3	CYMV-6	CuMV Kano	CMMV Gumel
IT86D-1010	1	1	1	1	1	2	1
IT86D-880	1	1	1	1	1	1	1
IT82D-849	1	3	2	1	1	1	1
IT83S-818	1	1	4	2	1	1	1
IT87D-611-3	2	1	4	1	1	1	1
IT82E-16	1	4	4	1	1	1	1
IT90K-59	1	5	1	2	1	1	1
IT86F-2089-5	1	1	1	1	1	1	2
IT82D-889	1	1	2	3	1	1	1
Ife Brown	3	5	5	5	4	4	1

1 = Resistant    2 = Moderately Resistant    3 = Moderately susceptible  
& 5 = Susceptible

Viruses:

- CAMV = Cowpea aphid borene mosaic,
- CYMV = Cowpea yellow mosaic,
- CUMV = Cucumber mosaic
- CMMV = Cowpea mild mottle virus

**Table 21. Performance of cowpea lines under *Striga* and *Alectra* infestation in the field at Kano, 1989\***

Variety	Days to 50% <i>Striga</i> infection	Parasitic weeds per plot*		Grain Yield kg/ha
		<i>Striga</i>	<i>Alectra</i>	
IT86D-534	66	135	1	656
B 301	-	0	0	599
Suvita-2	46	98	110	413
IT86D-472	66	56	0	559
IT86D-371	50	160	3	428
IT84D-666	50	92	0	410
IT82D-849	-	0	63	292
IT82D-957	35	324	20	35
IT86D-843	43	362	25	70
Vita-3	34	439	3	35
LSD - 5%	11	196	20	228

\*Average of 4 plots of 6 sq.m each, sprayed 2-3 times with insecticide

**Table 22. Performance (kg/ha) of *Striga* resistant cowpea varieties at different locations in Nigeria 1991**

Variety	Kano	Gumel	Maiduguri Reaction*	<i>Striga</i>
IT90K-59-5	1289	1653	1763	1
IT90K-59-3	1055	1544	1171	1
IT90K-101-1	1164	1081	1117	2
IT90K-102-6	1089	1657	1027	2
IT90K-82-2	1104	1320	778	1
IT90K-76-7	1114	1106	976	1
IT84S-2246-4	1028	583	733	4
LSD 5%	337	474	475	

\* 1 = completely resistant 5 = Highly susceptible

Sprayed 2-3 times with insecticide

**Table 23. Reaction of selected cowpea germplasm lines to *Alectra* and *Striga***

Germplasm line	Reaction	
	<i>Striga</i>	<i>Alectra</i>
TVu 1271	R	S
TVu 1272	R	S
TVu 1330	R	S
TVu 1331	R	S
TVu 1332	R	S
TVu 4642	R	S
TVu 8337	R	S
TVu 12415	MR	MR
TVu 12430	R	S
TVu 12431	R	S
TVu 12432	R	MR
TVu 12449	R	S
TVu 12470	MR	R
TVu 11788	MR	MR
TVu 9238	MR	R
TVu 13035	R	S
TVu 8453	R	S

R = Resistant, MR = Moderately resistant,  
S = Susceptible

**Table 24. Number of cowpea plants infested with *Striga* per plot (6m<sup>2</sup>) in different cowpea varieties at Zakpota (Republic of Benin)**

Varieties*	1990	1991	1992
IT82D-849	0.5	15.5	33.0
IT86D-371	32.5	25.8	-
IT86D-472	19.3	26.8	-
IT86D-534	22.5	20.0	-
IT84D-666	14.3	13.8	-
IT81D-994	0	0	0
IT81D-985	7.8	1.5	8.0
B 301	2.8	6.0	28.0
SUVITA-2	0.8	0	1.0
Tvx 3236	22.8	22.3	41.0

\* Sprayed 2-3 times with insecticide

**Table 25. Number of emerged *Striga* in susceptible windows (6m<sup>2</sup>) of different varieties and cultural treatment**

Treatment*	Year		
	1990	1991	1992
Fallow	78	131	189
TVx 3236	123	84	64
TVx 3236 + millet	89	46	30
IT86D-472	166	39	56
IT82D-849	81	46	36
B 301	115	32	27
LSD-5%	NS	NS	139

All sprayed 2-3 times with insecticide

**Table 26. Daily cumulative % from Day 6 to Day 15 wilting of nil watering regime (for the second screening in wooden boxes) and root characteristic of different cowpea varieties**

Genotypes	5	6	7	8	9	10	11	12	13	14	15	Root length	Root dry wt
IT84S-2246-4	0	2	14	39	76	91	96	98	98	98	100	49.5	0.13
Gorom Local	0	0	0	5	5	7	9	29	48	52	52	61.8	0.13
IT83S-818	0	0	0	20	80	100	100	100	100	100	100	97.7	0.2
IT82dE-18	0	0	26	63	79	87	95	97	97	97	100	47.4	0.2
IT82D-889	1	5	15	50	72	79	89	92	96	96	100	65.8	0.19
VITA 3	31	40	58	80	80	80	100	100	100	100	100	44.2	0.16
IT82D-1020	0	0	16	48	64	75	75	100	100	100	100	47.2	0.10
TN 5-78	0	2	9	16	21	21	26	68	89	89	100	73.6	0.17
TVx 3236	6	9	15	23	50	65	79	98	100	100	100	53.0	0.13
IT85D-3850-1	0	8	26	47	91	94	94	94	94	94	100	45.6	0.14
IT81D-994	0	0	3	3	6	6	12	21	33	60	79	84.1	0.18
IITA Local	0	21	28	42	63	63	100	100	100	100	100	20.8	.08
LSD-5%											18.6	26.6	.03

**Table 27. Mean grain yield (kg/ha) of some cowpea varieties over three different planting dates in dry season**

Variety*	Yield at different planting dates			
	19-1-91	31-1-91	20-2-91	31-1-92
IT86D-715	405	1104	24	-
IAR-48	573	1042	155	-
Local (Dan Ila)	1524	1119	-	851
IT84S-2246-4	1524	1980	196	1638
IT86D-719	1146	1269	236	-
IT90K-76	-	-	-	1570
IT90K-59	-	-	-	1148
LSD 5%	693	682	220	491
CV %	24	19	45	29

\* Sprayed 2-3 times with insecticide

**Table 28. Grain yield (kg/ha) of different varieties evaluated in 1992 Nigerian National Cowpea Short Duration Trial**

Number of Locations: 16, all sprayed 2-3 times with insecticides

	Mokwa	Badeggi	Makurdi	Samaru	Marafa	Bauchi	IITA Kano	Maiduguri	UnIbadan	Abeokuta
IT90K-101*	1156	1069	307	1421	1174	1716	1773	1350	709	2250
IT90K-59*	961	989	375	879	1011	1490	2106	1325	770	1250
IT86D-719	1080	1031	277	1135	947	1550	1290	1375	761	881
IT86D-721	1386	963	367	642	1188	1572	1560	825	724	1581
IT85D-3577	1412	1233	194	781	1172	1450	1614	1012	761	887
IT87D-941-1	1254	750	114	597	944	1749	867	950	812	1218
IFL 132 (Ife Univ.)	959	616	318	1453	836	966	1389	825	684	1193
IT90K-261-3**	1083	667	198	836	986	1756	767	650	686	1331
IT84S-2246 (check)	1220	698	174	767	877	1183	1029	625	683	1256
IT90K-76	1353	588	389	883	944	1231	694	425	738	1168
LSD-5%	502	330	171	386	393	598	652	595	199	957

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Table 28 (contd)

	Agdiwoye	Ile-Ife	Ado-Ekiti	Inua	Owerri Mean	Uyo	General	Reaction to:				
								Aphid	Bruchid	Thrips	Maruca	BB
IT90K-101	596	575	951	668	262	1419	1115	R	R	R	S	R
IT90K-59	754	466	993	668	664	1503	992	R	R	R	S	R
IT86D-719	319	713	956	542	371	1878	970	MR	S	R	LS	R
IT85D-3577	689	554	814	584	659	1252	942	R	S	S	LS	R
IT87D-941-1	538	238	768	542	484	1419	826	R	S	R	S	MR
IFL 132 (Ife Univ.)	393	618	688	-	178	1210	822	S	S	S	S	R
IT90K-261-3	427	476	672	-	309	1127	789	R	R	R	LS	R
IT85S-2246 (check)	202	463	450	876	520	1503	783	R	R	R	S	S
IT90K-76	288	463	672	-	252	1419	768	R	R	R	S	S
LSD-5%	206	180	401	282	200	367						

R = Resistant, MR = Moderately resistant, \* Also resistant to *Striga*.

\*\*Highly susceptible to *Striga* otherwise it has good level of resistance to many pests, LS = Low Susceptible,

S = Susceptible

**Table 29. Improved cowpea varieties from IITA selected by different national programs (revised July 1993)**

Country	Variety Released	Varieties under large scale On-farm test and seed multiplication for release
Angola	TVx 3236	
Argentina		IT82D-716
Belize	VITA-3	IT82E-18, IT82D-889, IT82D-789
Benin Republic	VITA-4, VITA-5	IT82E-32, IT81D-1137, IT84D-513, IT84S-2246
Bolivia	IT82D-442, IT82D-889	
Botswana	ER-7, TVx 3236	
Brazil	4R-0267-01F VITA-6, VITA-3	
Brazil	VITA-7, TVx 1836-013]	
Burkina Faso	TVx 3236, VITA-7 (KN-1)	
Burma	VITA-4 (Yezin-1)	
Cameroon	IT81D-985 (BR2) IT81D-994 (BR1) TVx 3236	IT82E-18, IT82D-812, IT81D-1137 TVx 1850-01E
Central Africa Rep.	VITA-1, VITA-4, VITA-5	
Chad	IT81D-994 (BR1)	
Colombia	IT835-841	TVu 352, TVu 256-1, TVu 335-1 TVx 1193-059D

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Table 29 continued

Country	Variety Released	Varieties under large scale On-farm test and seed multiplication for release
Costa Rica		VITA-1, VITA-3, VITA-6
Cyprus		IT81D-1137, IT85D-3577
El Salvador	TVx 1836-013J (Castilla deseda) VITA-3, (Tecpan V-3) VITA-5 (Tecpan V-5)	
Ecuador	VITA-3	TVx 1836-013J, TVx 3380
Equatorial Guinea		IT82D-885
Ethiopia		VITA-4, IT82E-16, IT82E-32
Fiji	VITA-1, VITA-3	
Ghana	IT82E-16 (Asonteni) IT83S-728-13 (Ayiya) IT83S-818 (Bengpla) TVx 1843-1C (Boafo) TVx 2724-01F (Soronko)	IT81D-1137 IT82E-16, IT82E-18, IT82E-32
Guinea	IT85F-867-5 (Pkoku Togboi)	84S-2246
Guyana	ER-7, TVx 2907-02D, TVx 66-2H, VITA-3	
Guatemala	VITA-3	
Haiti	VITA-5	
India	VITA-4, TVx 1502	TVx 1843-01C

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Table 29 continued

Country	Variety Released	Varieties under large scale On-farm test and seed multiplication for release
Jamaica	VITA-3, ER-7	TVx 2724-01F, TVx 1850-01E IT84S-2246, IT84E-124
Liberia	IT82D-889 TVx 3236, VITA-5, VITA-4, VITA-7	
Malawi		IT82E-25, IT82D-889
Mauritius	TVx 3236	TVx 1836-013J TVx 4654-44E
Mozambique	IT82E-18	IT82D-887
Nepal	IT82D-889 (Prakash) IT82D-752 (Aakash)	
Nicaragua	VITA-3	
Nigeria	IT84S-2246 TVx 3236, IT82E-60 IT81D-994, IT86D-719 IT86D-721	IT81D-994, IT82D-951 IT84E-124, IT84E-108, IT82D-716
Pakistan	VITA-4	
Panama	VITA-3	
Peru	VITA-7	
Philippines	IT82D-889	
Senegal	TVx 3236	
Sierra Leone	TVx 1999-01E	

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Table 29 continued

Country	Variety Released	Varieties under large scale On-farm test and seed multiplication for release
Somalia	TVx 1502	IT82D-889, IT82E-32, IT82D-1137
South Korea	VITA-5	
South Yemen	VITA-5, VITA-7	
Sri Lanka	IT82D-789 (Wijaya) IT82D-889 (Waruni) TVx 309-01G, VITA-4 TVx 930-01B, (Iita)	
Surinam		IT82D-889, IT82D-789
Swaziland	IT82E-18, IT82E-32 IT82E-71	IT82E-18, IT82E-27
Tanzania	TK-1, TK-5 IT82D-889 (Vuli-1)	IT82D-890
Thailand		VITA-3, IT82D-889
Togo	VITA-5, TVx 3236	
Uganda	TVx 3236, IT82E-60	
Venezuela	VITA-3	IT81D-975, IT82D-504-4
Yemen	TVx 3236, IT82D-789 VITA-5	
Zaire	IT82E-18	VITA-5, VITA-7, TVx 3236, IT82E-32
Zambia	TVx 456-01F, TVx 309-1G	IT82E-32, IT82E-16 TVx 3236, TVx 30901G, IT82D-889
Zimbabwe		ER-7, VITA-4, TVx 3236, IT81D-935, IT82D-952, IT81D-1157

# FIGURES

## MILLET - COWPEA INTERCROPPING

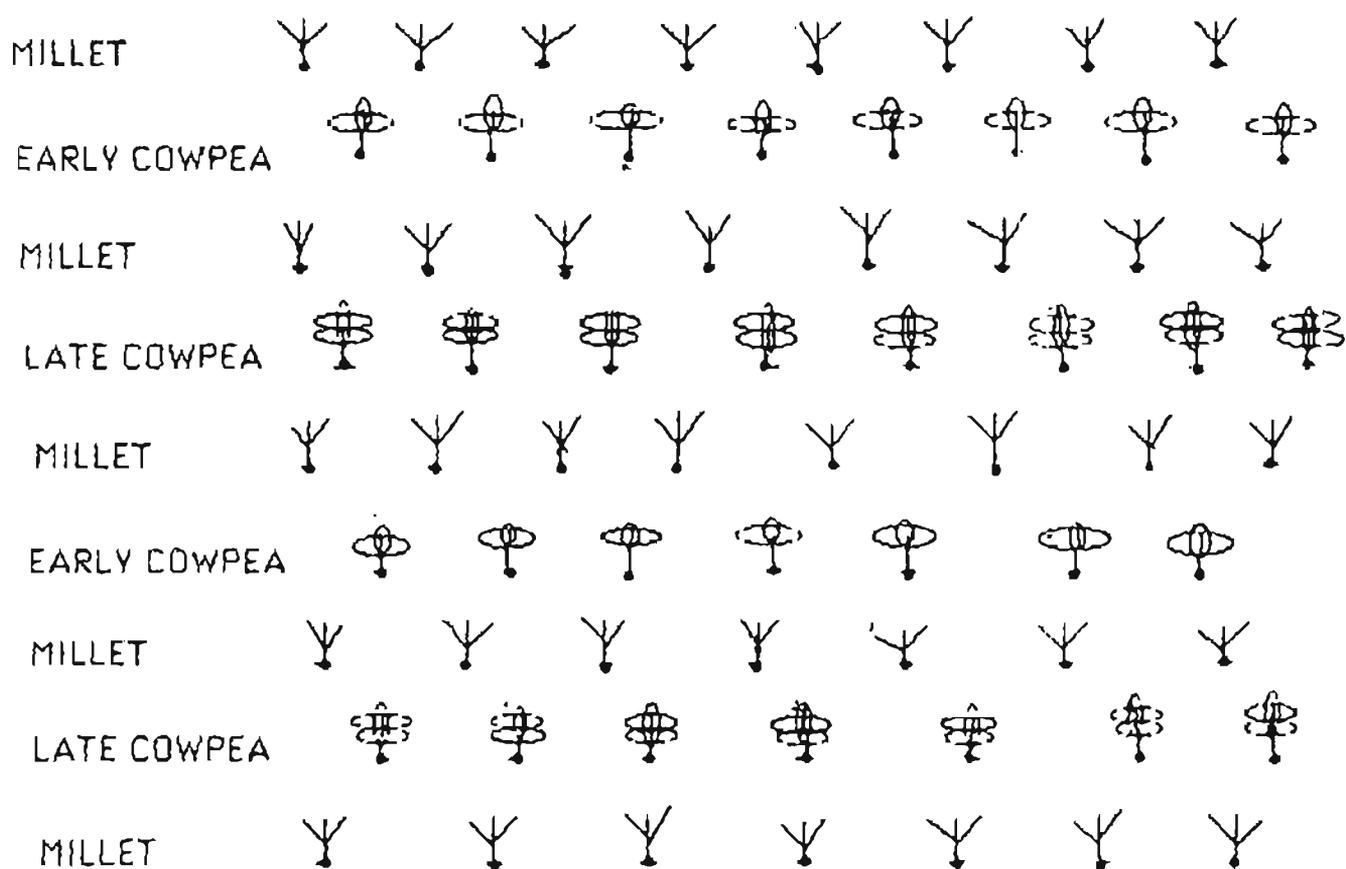


Fig. 1 Traditional intercropping systems involving relay with early and late cowpeas in millet fields

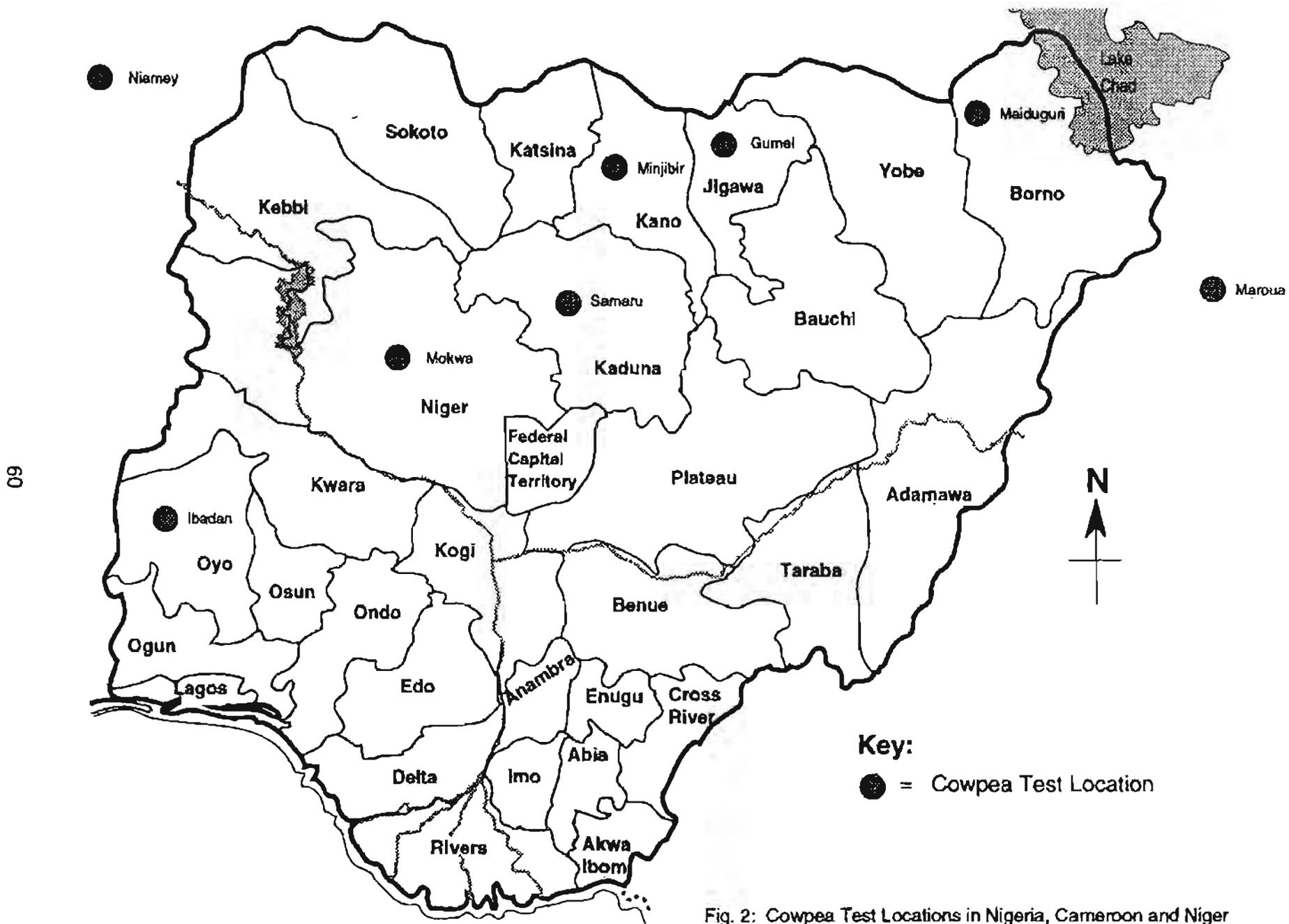


Fig. 2: Cowpea Test Locations in Nigeria, Cameroon and Niger

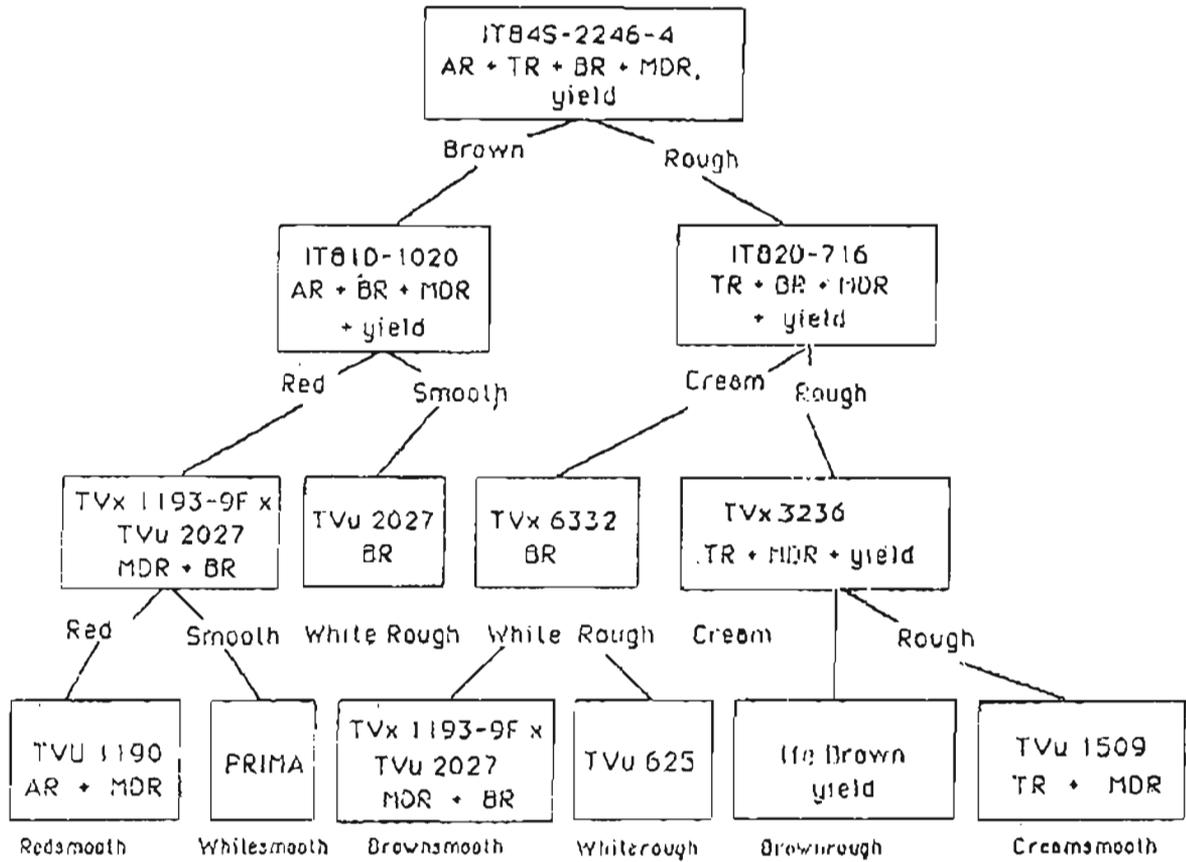


Fig. 3 Pedigree of IT84S-2246-4 and sequence of selection

Resistances:

AR = Aphid

TR = Thrips

BR = Bruchid

MDR = Multiple Disease

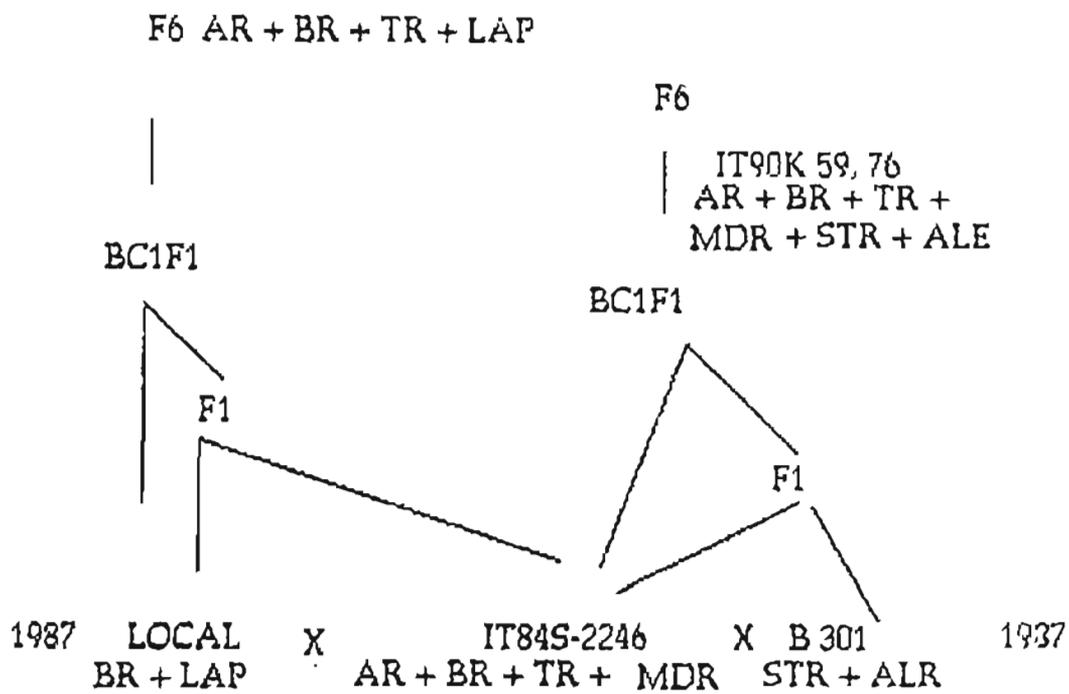
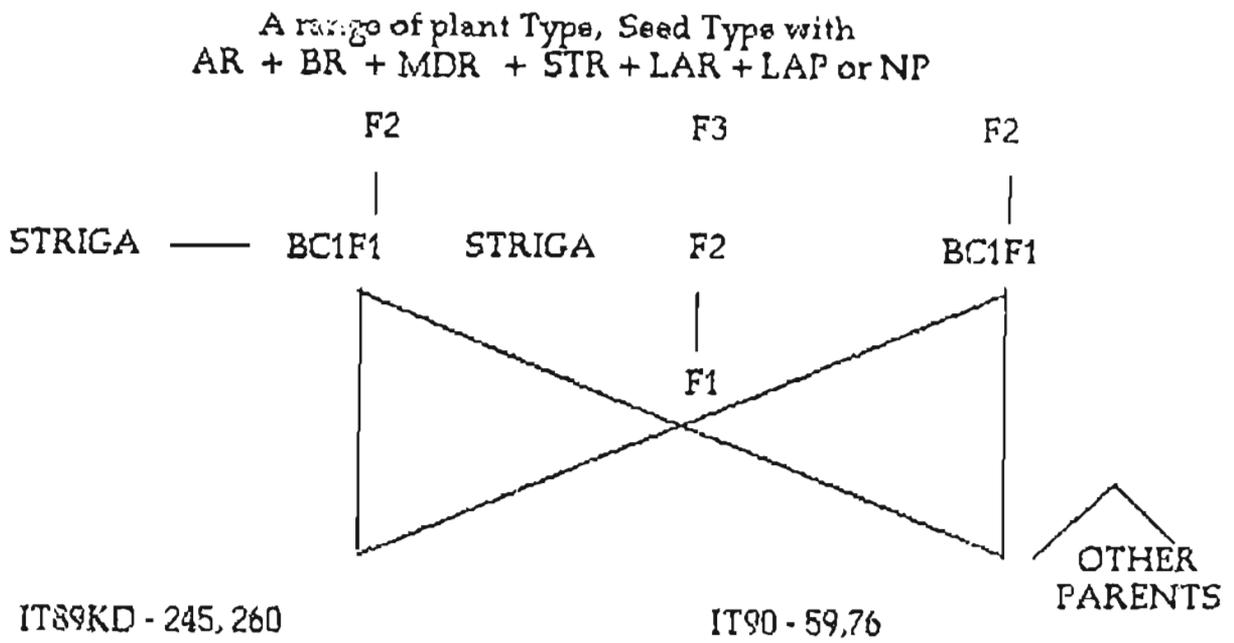


Fig. 4 Pyramiding desirable genes in a range of plant types

Resistances:

- |   |                        |
|---|------------------------|
| AR = Aphid                                | BR = Bruchid           |
| TR = Thrips                               | MDR = Multiple Disease |
| SRT = <i>Striga</i>                       | ALR = <i>Alectra</i>   |
| LAP = Local Adaptation and Photosensitive |                        |
| NP = Non-Photosensitive                   |                        |

## Physiological Studies of Drought Tolerance

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# ANNEX

# PHYSIOLOGICAL STUDIES OF DROUGHT TOLERANCE<sup>1</sup>

## 1. INTRODUCTION

Rainfall in the Sudan Savanna is both small in absolute amount and erratic in distribution. As a result, even though cowpea is a crop which is adapted to the semi-arid tropics, there are occasions during crop growth when dry soil conditions may adversely affect the crop's performance. The improvement of drought tolerance in cowpea is therefore a justifiable aim and is part of IITA's cowpea breeding programme. This paper reports some physiological studies which were undertaken at IITA's Kano Station, in relation to this aspect of breeding. The work was a collaborative project with the Tropical Agricultural Research Centre (TARC), Japan

## 2. DEVELOPMENT OF SCREENING METHODS

### 2.1 Field and pot screening

As a first step, evaluation methods for plant tolerance of dry conditions were investigated in the field and in pots experiments. In the dry season of 1990, about 900 cowpea germplasm accessions from the IITA Genetic Resources Unit were planted in the field at Kano Station. To secure germination and early growth, the field was watered for about 2 weeks after sowing. Thereafter, the seedlings were left unwatered until the evaluation at about 3 months after sowing. In this trial, a wide range of plant responses to dry conditions were observed (**Photo 1**) suggesting the possibility of breeding more tolerant cultivars. The precision of evaluation was affected by the unevenness of residual soil moisture. For this reason, in 1991, evaluation was tried with potted seedlings in a glasshouse. Based on the observations of the field evaluation in 1990, 25 cowpea lines were chosen to cover the range of plant responses, from highly tolerant to dry conditions to highly susceptible. Seeds were planted in small pots with a fixed weight of dry soil in order to regulate soil moisture by weighing procedures. Seedlings were grown with enough water for about 2 weeks. Then they were subject to three watering

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<sup>1</sup>. The research reported here was carried out by Dr Iwao Wantanabe, a Visiting Scientist from the Tropical Agriculture Research Centre (TARC), Japan working at IITA Kano Station and at TARC, Japan during 1990 and 1991

regimes for 2 weeks to create three soil moisture content treatments. Each morning, individual pots were weighed on an electric balance. The soil moisture was adjusted by adding water so as to reach three fixed levels of soil moisture, 5% of pot weight, 3% of pot weight and 2% of pot weight.

## **2.2 Results**

At the end of the stress treatment, some lines were completely dead (tolerance score 1) and some were less affected and alive (score 5), albeit with some adverse effects on leaf development (**Photo 2**). The tolerance of dry conditions was best discriminated under the 3% soil moisture level treatment (**Table 1**). The correlation coefficient between the evaluation scores in the field experiment in 1990 and those in the pot experiment in 1991 was highly significant ( $r=0.663^{**}$ ,  $n=25$ ). The pot evaluation was found to be reliable in the repeated evaluation of the same materials, where a highly significant correlation ( $r=0.655^{**}$ ,  $n=98$ ) was observed between the repeated experiments.

## **2.3 Conclusion**

It was concluded that field evaluation in the dry season could be used for a first round screening of a large number of materials and that the pot evaluation at 3% soil moisture in a glasshouse is recommended for precise evaluation of a smaller number of materials, preferable less than 100 lines at one time.

# **3. SHOOT AND ROOT STUDIES**

## **3.1 Grafting experiment**

In order to clarify the specific roles of tops and roots in relation to drought tolerance, a grafting experiment was carried out in 1992 at TARC in Japan.

Four highly tolerant lines were paired up with four highly susceptible ones, making four pairs from eight lines. At the completion of the expansion of the first true leaf of each seedling, shoots were grafted mutually within pairs. In 10 days after grafting, when grafted plants began to grow vigorously again,

they were subjected to the 3% soil moisture treatment for 2 weeks, (as described in Section 2.1).

In each of the four pairs, the tolerance of soil moisture conditions of the grafted plants was completely dependent on the top (**Photo 3**). That is, the top of a tolerant line remained tolerant when grafted on the root of the susceptible one. Conversely, the top of the susceptible line when grafted onto the root of a tolerant line, conferred susceptibility on the whole plant. From this experiment it was concluded that when both the root zone and the soil moisture are limited, it is tops and not roots which determine the plant characteristic in respect of drought tolerance.

### 3.2 Root growth study

Comparisons of root growth in conditions where rooting was unrestricted were made between lines of different tolerances, both in stressed and stress-free conditions. Five lines, two highly susceptible and three highly tolerant ones, were grown outdoors in transparent tubes of length 1m and diameter 250 mm. They were inserted in long holes in the soil so as to keep the root zone dark and cool. They were protected from rain with a polyethylene cover. In the stressed plot, no water was given after germination. In the stress-free plot, soil moisture was maintained at 21%.

Root length from soil surface to the furthest point of root extension down the tube was recorded over a two week period. Root growth of highly susceptible lines was severely retarded in the water stressed treatment. That of highly tolerant ones, on the other hand, was little affected by the stress. Roots were roughly double the length of the water stress susceptible lines (**Table 2** and **Photo 4**). In the case of Suvita-2 (highly tolerant), root growth in the stressed plot was even better than that in the stress-free plot.

### 3.3 Conclusion

From these two experiments, the roles of tops and roots with respect to drought tolerance appeared to differ in their importance depending on the time course of the development of drought. The pot experiments on grafting examined plant responses to the onset of drought because the pots were small and the duration of the experiment was only a few days. In these circumstances, the soil moisture of the root zone was consumed rapidly. Drought tolerance of tops seemed to be playing a more important role than

roots at this stage, but highly tolerant lines survived 5 to 6 days longer than highly susceptible ones.

In the rooting studies, where roots had opportunity for unlimited extension down into the soil, roots seemed to play a more important role than tops. In non-stressed soil moisture conditions, roots elongated at about 2cm per day. When moisture stress was imposed, root extension in susceptible lines slowed to 0.9cm per day but in tolerant lines it remained more or less the same at 2cm per day. Thus the roots of highly tolerant lines were able to reach deeper into the soil. In a field situation, this might ensure plant survival because the roots might find water, and even nutrients, in deeper parts of the soil profile.

Thus it could be postulated that the tolerance of the plant top plays a initial role in the plant survival in dry conditions and subsequently, new roots ensure longer term plant survival.

#### **4. FUTURE WORK**

Further studies will be undertaken on the mechanism of tolerance, especially in tops, to develop a more simple and efficient method for screening and to obtain a better understanding of drought tolerance mechanisms.

**Table 1. Pot evaluation of drought tolerance of cowpea at three levels of soil moisture**

No.	Line (TVu No)	Percent soil moisture			Score in field evaluation in dry season
		5	3	2	
1.	11982	5.0	4.7	1.0	4
2.	14914	4.7	4.7	1.0	5
3.	11979	5.0	4.0	1.7	5
4.	9167	5.0	4.0	2.0	3
5.	6914	4.3	3.7	1.0	5
6.	7841	4.5	3.0	1.0	5
7.	59	5.0	2.7	1.0	2
8.	7381	3.7	2.7	1.0	3
9.	8715	3.0	2.7	1.0	3
10.	8713	5.0	2.3	1.0	5
11.	433	5.0	2.3	1.0	4
12.	928	5.0	2.0	1.0	4
13.	127	5.0	2.0	1.0	1
14.	85	5.0	2.0	1.0	4
15.	7878	3.0	2.0	1.0	2
16.	760	3.0	2.0	1.0	2
17.	8885	4.3	1.7	1.0	4
18.	7426	3.0	1.7	1.0	3
19.	8365	4.7	1.3	1.0	2
20.	7778	3.7	1.3	1.0	1
21.	9357	3.0	1.3	1.0	2
22.	12355	4.7	1.0	1.0	1
23.	7758	3.7	1.0	1.0	3
24.	8401	3.0	1.0	1.0	1
25.	8048	3.0	1.0	1.0	1
Variance		0.70	1.25	0.05	

Scores: 1 = highly susceptible      5 = highly tolerant

**Table 2. Time course of soil depth reached by the longest root (average of two pots)**

Line	Day:	Distance from soil surface (cm) on:				
		1	4	7	10	14
<b>A. Without water stress</b>						
<i>Highly susceptible</i>						
TVu 7778		19.5	32.5	41.5	53.0	59.0
TVu 9357		12.0	17.5	24.5	32.0	39.0
Mean		15.8	25.0	33.0	42.5	49.0
<i>Highly tolerant</i>						
TVu 11979		17.5	26.0	33.0	48.5	54.5
TVu 14914		14.0	23.0	32.5	41.0	44.5
Suvita-2		9.5	13.0	19.0	27.0	36.0
Mean		10.3	20.7	26.2	38.8	44.3
<b>B. With water stress</b>						
<i>Highly susceptible</i>						
TVu 7778		6.5	6.5	10.0	16.0	24.5
TVu 9357		6.0	10.5	17.5	25.5	32.0
Mean		6.3	8.5	13.8	20.7	28.3
<i>Highly tolerant</i>						
TVu 11979		16.0	28.5	38.5	44.5	52.5
TVu 14914		12.5	21.0	30.0	36.5	45.0
Suvita-2		18.5	30.0	41.0	49.0	52.5
Mean		15.7	26.5	36.5	43.3	50.0

# PHOTOGRAPHS



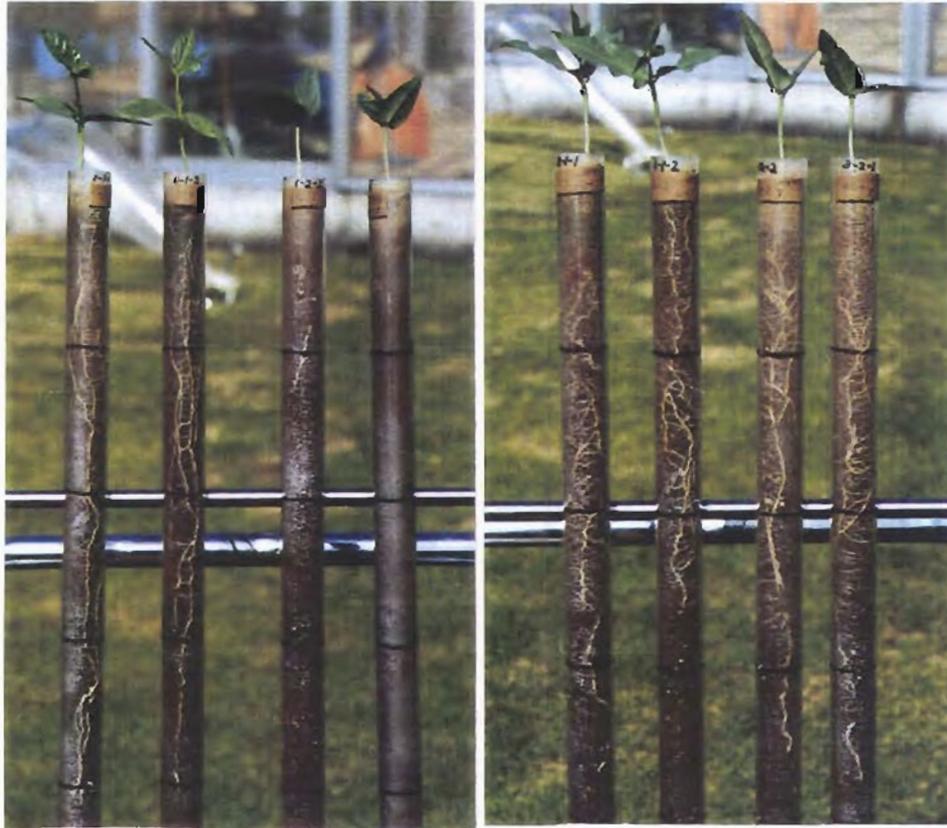
Photo 1. Field evaluation of drought tolerance of cowpea in dry season



Photo 2. Pot evaluation of drought tolerance of cowpea at a moisture level of 3 %  
1: highly susceptible  
5: highly tolerant



Photo 3. Drought tolerance of grafted cowpea  
1 intact: TVu 9357 (highly susceptible)  
5 intact: TVu 11986 (highly tolerant)  
1/5 : TVu 9357 grafted on the root of TVu 11986  
5/1 : TVu 11986 grafted on the root of TVu 9357



stress-free      stressed  
TVu 7778 (highly susceptible)

stress-free      stressed  
TVu 11979 (highly tolerant)

Photo 4. Root growth as affected by drought tolerance and water stress

